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JANUARY, 1907

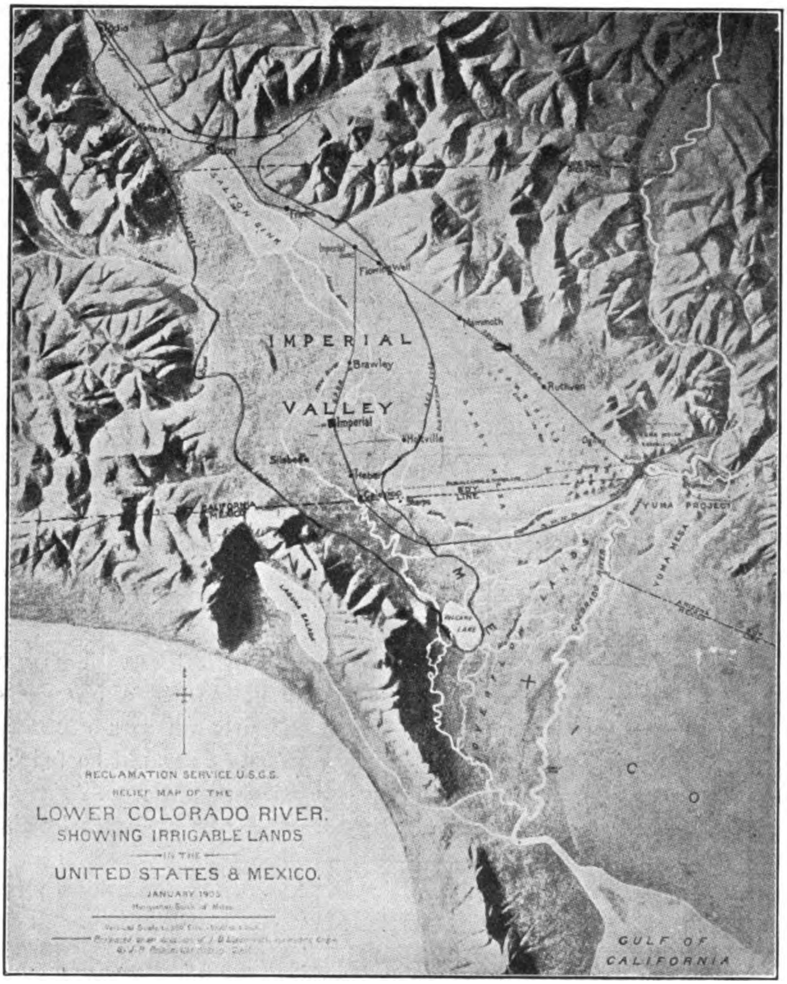
THE POSSIBILITIES OF SALTON SEA

By CHARLES ALMA BYERS

LOS ANGELES, CAL.

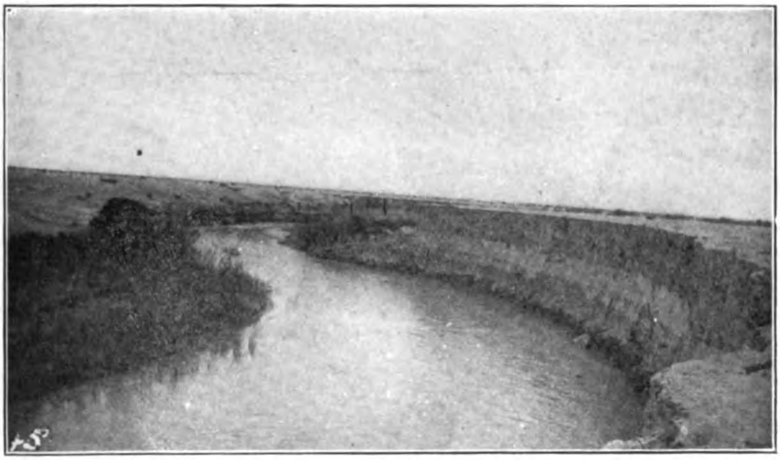
THROUGH temporarily losing control over the Imperial Valley irrigation system in southern California, there has been suggested the possibility of creating an immense inland sea. This sea would extend from Volcano Lake in Mexico to a point a few miles north of Indio, California, and would spread over an area of 1,700 square miles, with a maximum depth of 280 feet. It would be fed by an irrigation canal intersecting the Colorado River near Yuma, Arizona, and its overflow would be carried into the Gulf of California by the lower part of the same river. It would submerge many acres of irrigated and irrigable land, about a dozen fair-sized towns of more or less importance, several miles of the Southern Pacific Railroad, and a number of rich deposits of valuable minerals. And the ability to create such a sea or lake lies simply in abandoning the present effort to regain control over this irrigation system.

Dealing still further with possibilities of this nature, it may be pointed out that the feed canal of this inland sea could be widened and dredged; and thereby could be created a channel sufficient in dimensions for the entry of boats from the Gulf. This would make it possible for coast steamers to ply between ports on the Pacific Coast and a lake port that might be established near the present site of the town of Indio, at the foot of the eastern slope of the Sierra Madre Mountains, and with a latitude almost parallel with the city of Los Angeles. It is true that if the effort now being made to regain control over this rebellious system of irrigation should be abandoned to-day, and nature be permitted to reign supreme and unaided by man, it would be several years before the Colorado River could possibly complete the creation of the lake;

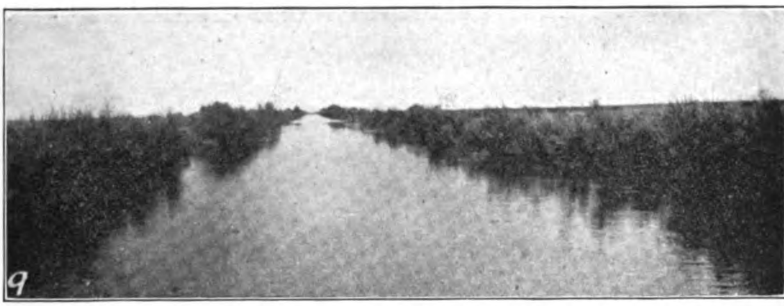


but since all this territory lies beneath the level of the sea, it is even possible for engineers to change the course of the lower part of the river, so that it would carry water from the Gulf of California to assist in the lake's completion. It may be remarked in this connection, however, that there is no probability at present of such a series of possibilities being permitted to materialize. In the light of present considerations, the value of the land and its products far outweighs the possible benefits of such a lake and inland port. Nevertheless it is a matter worthy of consideration.

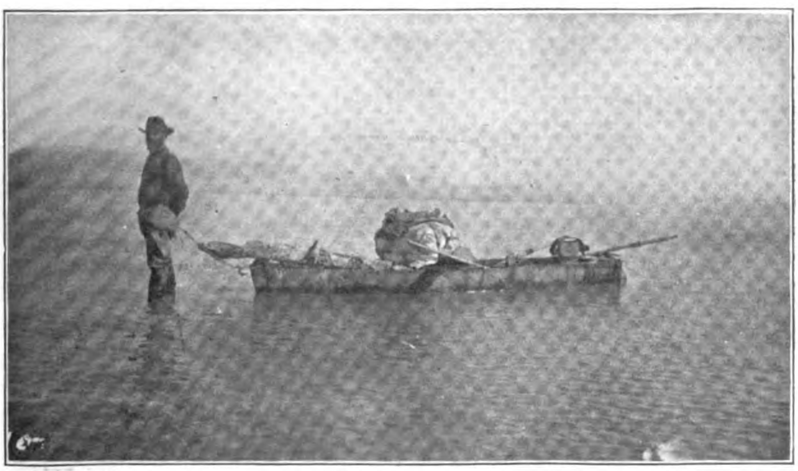
The Colorado Desert, of which the greater part would be covered by this inland sea, is bounded on the west by the Sierra Madre Mountains, on the north and east by the San Bernardino and Riverside Ranges, and on the east by the Colorado River. As, therefore, would be



NEW RIVER BELOW ROCKWOOD. January 16, 1904.



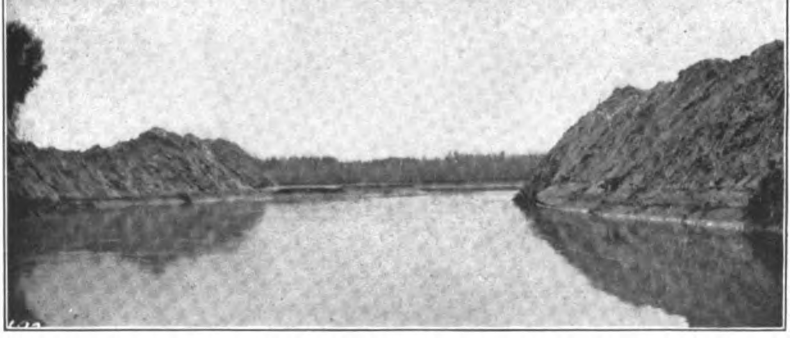
MAIN CANAL EAST OF CALEXICO. December 16, 1904.



EXPLORING SALTON SEA FOR THE SOURCE OF THE WATERS. January 13, 1905.

MEXICANS LIVING ALONG CANAL IN MEXICO. January 21, 1905.

INTAKE No. 1, from North Bank. January 22, 1905.



INTAKE No. 3, looking out toward the river. February 15, 1905.

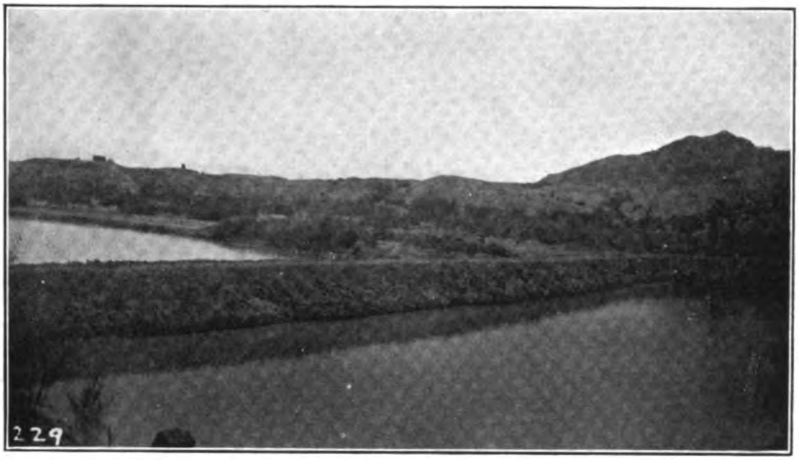
shown in a relief map, it is in the shape of an acute triangle, with its base resting upon the Colorado River, on the east side, and extending northwest and up the Coachella Valley toward Mt. San Jacinto. The land slopes gradually from the river northwest to the Salton Sink, which at the lowest point is 280 feet below sea level. Yuma, Arizona, lies at the northeast corner of this triangle, and is 137 feet above sea level, which, therefore, gives the feed canal, created for irrigating, a fall of 417 feet.

Indio, at the extreme northwest point of the triangle, is 22 feet below sea level, while Volcano Lake, Mexico, is found to be very close to sea level. The town of Indio is the end of a division of the Southern Pacific Railroad, where the company has machine shops and maintains a large force of men. It is also a health resort, and has a fine hotel and sanitarium. The other towns of this sunken area, which would be submerged by such a lake, are: Salton, 265 feet below sea level; Walters, 189; Thermal, 121; Imperial, 65; Alamo Bonito, 186; Coachella, 65; Mortmier, 248; Volcano Spring, 265; Fish Spring, 230, and Mecca, 18.

The town of Imperial, located near the center of the Imperial Valley irrigation colony, is fast becoming a very important little city. Four years ago it was unknown. Its site was only a part of the bare Colorado Desert. An examination of the soil of this vicinity, however, revealed the fact that the only thing necessary to make it productive was water, and in consequence a company was organized to install a system of irrigation. A canal was dug that intersected the Colorado River near Yuma, and by the water thus supplied the region was awakened into life and fertility. As a result, in the past four years, the town of Imperial has come into being, and about 110,000 acres of the surrounding land have been converted into a prospering farming community, with a total population of over 10,000 persons. And the limit has by no means yet been reached, for there is much more of the region in a reclaimable condition.

Up to the time that this irrigation system placed Imperial upon the map, the most important industry on the Colorado Desert was the salt works at Salton. Salton Sink was a vast dry lake of solid salt, and thousands upon thousands of tons of it were mined by simply scraping it up into piles. This industry furnished employment to a large corps of men, and the town of Salton came into being as the result of its being made the headquarters of the New Liverpool Salt Company.

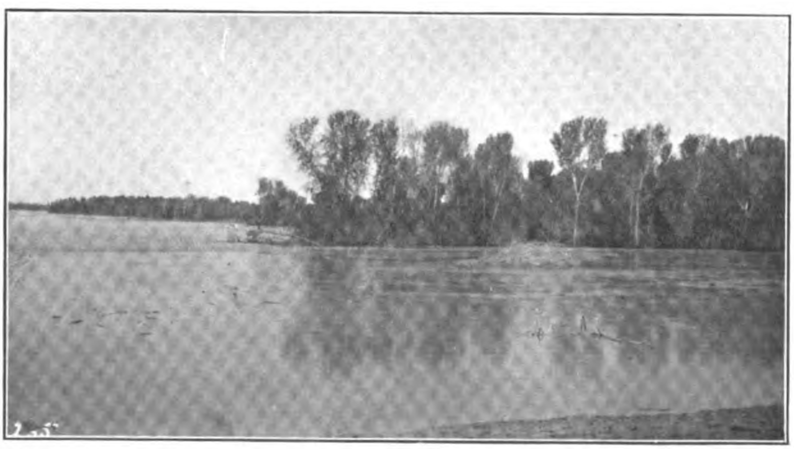
But Salton at present is dead. The town and the works are buried in a grave of water. The person who journeys thither to-day looks upon a vast lake. The homes are deserted, the salt works are abandoned, and Salton Sink, once a dry lake of pure salt, lies transformed



EARTH DAM ACROSS INTAKE NO. 1. May 29, 1905

into a billowy sea. Imperial not only became its peer in importance, but its annihilator as well. The savior or the creator of the one became the destroyer and the grave of the other. It was water from the Colorado River that brought Imperial into being, and it was water from the same source that gave Salton its watery burial.

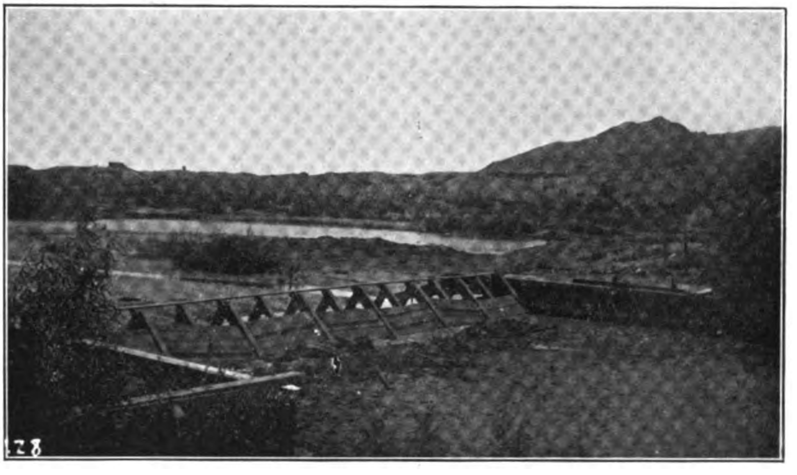
It was not with the spirit of rivalry, however, that Imperial wrought Salton's annihilation. Instead, it is said to have been due to neglect. The main canal for the Imperial Valley irrigation system, which makes use of about fifty miles of what was once the channel of the old Alamo River, draws its water from the Colorado River at a point about ten miles below Yuma, and near the international boundary line between California and Mexico. At this intersecting



VIEW LOOKING SOUTH ACROSS INTAKE NO. 3. May 29, 1905.

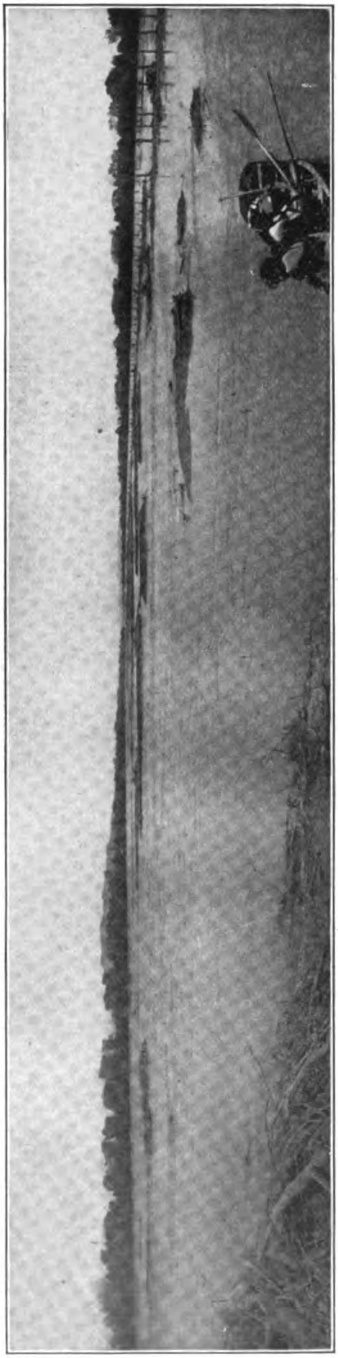
point there are three intakes or openings, for each of which there should have been provided a head-gate. This was not done, however, and over a year ago, during high water in the Colorado, these intakes began to admit more water than was necessary for use for irrigation. This surplus, which at times was very large, naturally sought the lowest part of the desert, and in consequence Salton Sink became 'Salton Sea.'

Edwin Duryea, Jr., C. E., of San Francisco, who has made a careful study of the situation for the Southern Pacific Railroad, says that since October, 1904, when the canal first began to carry a surplus, the water in Salton Sink has steadily risen at the average rate of over one half inch per day. At times, during floods, this has even been

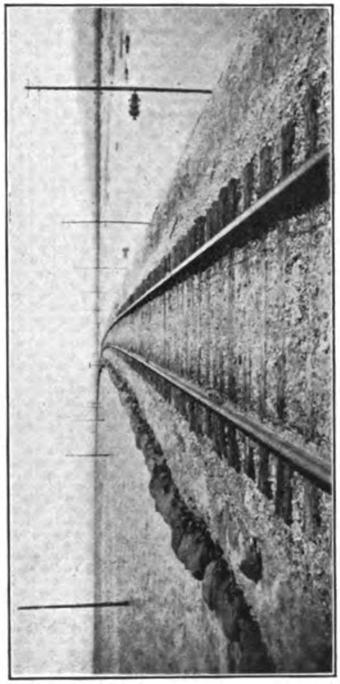


UNUSED HEAD-GATE BETWEEN INTAKES NOS. 1 AND 2. May 29, 1905.

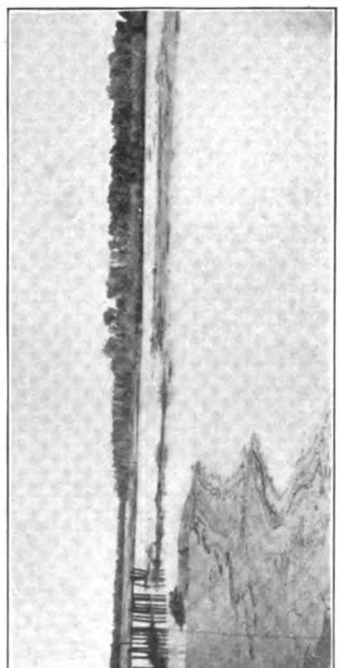
temporarily increased to the rate of two inches per day. The water used by the irrigation system varies with the seasons from nothing in rainy weather to about 1,000 cubic feet per second; and Mr. Duryea, to show the variations in the surplus of water carried into the region, has made a number of measurements that leave no doubt as to the importance of the danger threatened. On February 14, 1905, the canal received 2,500 cubic feet per second, while about 30,000 cubic feet passed down the river; June 5, about 8,000 cubic feet went to the canal per second and 60,000 down the river; July 18, 18,000 to the canal and 7,000 down the river; October 17, 7,000 to the canal and none down the river; November 20, 6,000 to the canal and 128 down the river; December 13, 10,300 to the canal and none down the river. On November 29, there was a flood in the Colorado River, and it was estimated that the river at Yuma carried a maximum flow of 110,000 cubic feet per second, of which about one-half went into the canal, and thence into Salton Sea.



View from Island in River looking North toward the Third Attempt. July 18, 1905.



Sand-bags along S. P. Track, looking West. July 16, 1905.



View looking South across Intake No. 3 and Remains of Second Attempt. July 18, 1905.

S. P. TRACK NEAR SALTON, looking West. October 19, 1905.

The result of this surplus flow, due to the loss of control over the irrigation system, has been the creation of a lake averaging about forty miles in length by ten miles in width, and therefore covering an area of about 400 square miles. The Southern Pacific Railroad has been compelled to build many miles of new road to skirt this embryo lake, and the salt works of the New Liverpool Salt Company are immersed in more than twenty feet of water. This was the condition at the close of the year 1905, and the size of the lake is still increasing.

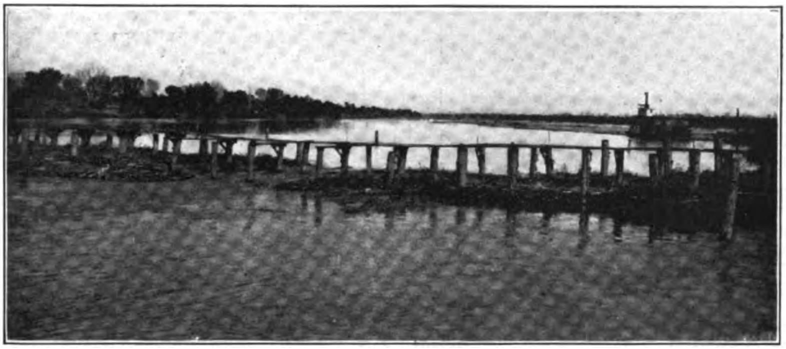
The first attempt to control this rebellious system of irrigation was made in March, 1905. It was a very frail effort, however, and the construction was washed away before it was entirely finished. Four other attempts followed in almost monthly succession, and each in turn met the same fate as the first. Then came the sixth. It, unlike the former ones, was undertaken on a larger scale and with a fuller realization that the problem to be confronted was a grave one. A large force of men was employed, and the attempt was prosecuted with vigor. Two hundred men, twenty teams, two pile-drivers and two stern-wheel river steamers were employed, and the work was carried on night and day. The intention was to construct a 600-foot dam across the west branch of the river, and thereby control the canal service by diverting the water into the east branch—except at such times and in such quantities as were necessary for irrigation. The dam was made of brush woven into mats and reinforced by several rows of piles. The flood of November 29, however, came before it was finished, entirely covering the work with water and washing it away, and thus destroying the sixth attempt.

But the effect of this failure was only to more thoroughly convince the Southern Pacific Railway Company, which had assumed charge of the work in June, that the canal system must be controlled. The company almost immediately, or in December, 1905, awarded a contract for the seventh attempt, and in January of 1906 work was again commenced.

INTAKE No. 2, looking out toward the river. October 17, 1905.

The seventh attempt was pushed with even greater determination than the sixth. A larger corps of men was employed, and the work was planned upon a more substantial scale. It progressed quite slowly on account of high water at different times, but at last it is finished, and the engineers feel confident that the problem, after a year and a half, is now solved. The gates were declared completed about the middle of July, but on account of the swollen condition of the Colorado River they have not yet been tested. The gate on the California side is constructed to admit 20,000 cubic feet per second, and the present flow of the river is in excess of 30,000 cubic feet per second. As soon as the river goes down to its normal condition the gate will be tested, and the engineers who have managed its construction assert that there is no possibility of its not standing the test.

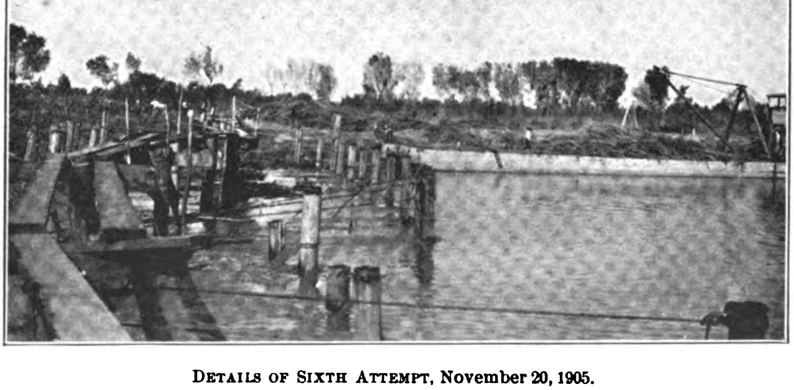
DETAILS OF SIXTH ATTEMPT, November 20, 1905.



Details of Sixth Attempt, November 20, 1905.

The total cost of the seventh and last attempt to control this irrigation system has been $40,000, or thereabouts. There are two head-gates—one, of concrete, on the California side, and one, of wood, on the Mexico side. The one of concrete is built to stand the greater portion, by far, of the strain, and it has every appearance of being amply substantial. The cost of this gate alone was $24,770.47. It necessitated the excavation of 12,637.1 cubic yards of earth and 5,700.81 cubic feet of rock, and required the use of 1,335 barrels of cement, 1,204.85 cubic yards of sand, gravel and rock, 25,722 pounds of steel bars for reinforcement and 791 pounds of expanded metal for gate facings. The work is being engineered by Mr. C. F. Cory, an engineer of wide repute.

Although these dams or head-gates seem to promise a solution to the Salton Sea problem, there is nevertheless excuse for apprehensions of further trouble. The banks of the Colorado River in this vicinity are soft and gravelly and very easily eroded, and on this account there will always be the possibility of new channels being cut around these head-gates, especially during flood seasons.



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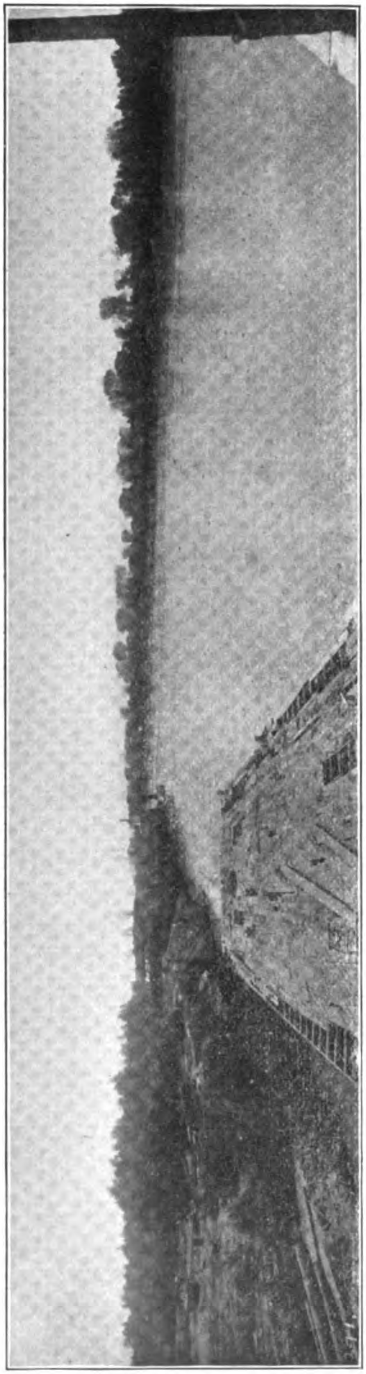
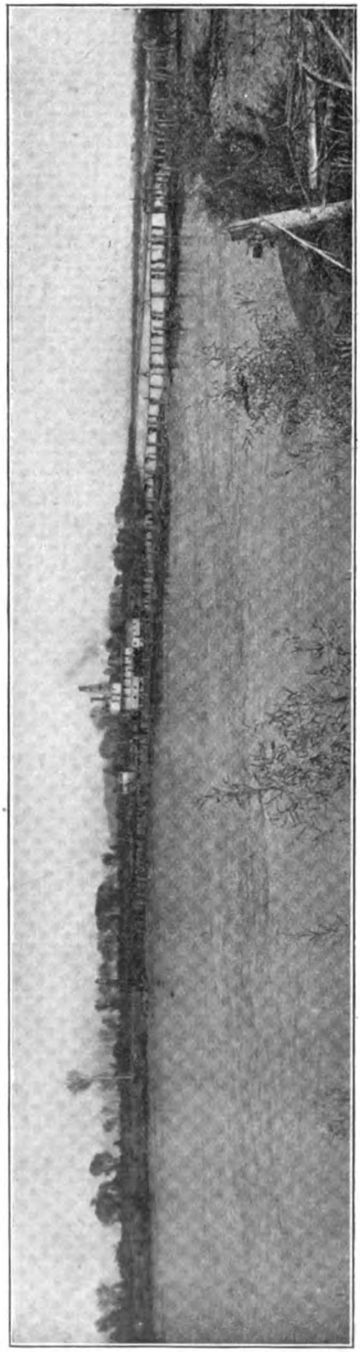


View Down West Channel of Colorado River, showing site of sixth attempt to control the Canal. October 17, 1905.



View of Sixth Attempt, looking North from Island. November 20, 1905.

Whether or not this attempt, when tested, proves successful, however, the damage being continually done to this region can not be expected to end at once. Several hundred thousands of dollars damage has already been done by the truant river, and even if the surplus flow into the Sink is stopped by the new gates, the lake that covers Salton and its salt works will still remain, which evaporation, almost unaided, will have to drain. It will therefore be a long time before Salton, the submerged headquarters of the New Liverpool Salt Works, can be replaced upon the map and the Southern Pacific Railroad reconstructed upon its old road bed.

The damage that threatens this sunken area, in case the river is not controlled, has already been briefly mentioned. If for some unforeseen and improbable cause the present attempt should fail or be abandoned, and no other attempts inaugurated, the water would gradually cut the present irrigation canal so deep that the entire flow of the river would be side-tracked into Salton Sea. The water would slowly rise until a lake would be created as large in area as, or larger than, Great Salt Lake of Utah, and the entire Imperial Valley, which thus far has not suffered, would be covered with water. The lake would not only rise to the sea-level line, but instead, on account of the elevation of the enclosing rim, it would have to reach to an elevation of fifteen or twenty feet above sea level, at which point it would overflow the south rim near Volcano Lake and pass southward until it would again enter the Colorado River near the Gulf. Should it be the desire at any time to convert this area into a sea-level lake, this outlet channel, which would pass over very loose soil, could be dredged very easily into a sea-level inlet from the Gulf.

To fill this sunken area with water from the Colorado River would require many years. The average flow of the river during a year is said to be about 15,000 cubic feet per second. This entire amount conveyed into the lake would be subject to a very great shrinkage from evaporation, and it is even possible that this loss would become so great after the lake had spread over a certain area as to equal the inflow from the river, although such is hardly probable. In any case, all attempted computations of such nature would necessarily be very inaccurate, and may as well be omitted.

In studying the possibility of this area becoming the bed of an inland sea there are even more considerations to be met than are offered by the Imperial Valley land colony and the salt works at Salton. Gilbert E. Bailey, M. E., of Los Angeles, a recognized authority on the mineral resources of California, has made a thorough study of this region, and to the writer he has furnished a partial list of its possibilities in this direction. In addition to the salt deposits, large quantities of nitrate, sulphate and carbonate of soda are found at various points along the rim of the desert, and in the southern part there are about 300 acres covered with mud volcanoes or geysers that spout forth mud of various colors and consistency, containing rare minerals which some day may become of importance. Oil-bearing rocks are found along the west side, forming a belt at the foot of the mountains and extending into the area lying below sea level, from which ooze heavy asphaltic oils, and which will some time develop into a rich oil-producing district. South of the California line, in Mexico, and lying below sea level, there are also valuable and extensive deposits of sulphur; and then in the surrounding mountains, which, however, would not suffer from the lake, are found large deposits of gold, silver and copper and mines of kunzite and tourmaline gems.

Altogether, this is an interesting country. It offers many realities, and as many, or more, possibilities. At present it is battling with an unusual problem, and we are assured by engineers that it stands on the eve of victory—at last. It has met defeat bravely six times, and therefore let us hope that the seventh attempt will be crowned with reward.

Author's Note.—About the first of last November, shortly after this article was written, the dams and headgates constructed to shut the Colorado River out of Salton Sink were put into use. Up to this time the Southern Pacific Company, after finishing the headgates mentioned, had continued work until it had practically diked the river for a distance of more than ten miles, and had expended upon the work a sum in excess of $1,500,000. The test of the completed work at that time seemed to assure the successful capture of the runaway river, and there was general rejoicing. A month later, however, the river rose to flood tide, and on the night of December 7, last, it again broke through its natural channel bounds and is again pouring into Salton Sink. The condition to-day is as bad as it was six months ago, and the possibilities of a permanent 'Salton Sea' are now more pronounced than ever. The river must be controlled within six months, or the Imperial Valley will suffer greatly. The Southern Pacific Company, at present, hesitate to again fight the river, and it is probable that the United States government will be asked to lend assistance. The recent break occurred just below the new dike, and has already eroded a canyon-like channel. As pointed out by the writer, the banks of the Colorado River in this vicinity are low and of a very loose material, consequently easily eroded, and to assure a lasting solution to the problem about twenty more miles of dike will be necessary. This, too, must be built soon—before the river channel above the break is cut much deeper.

THE SANITATION OF AIR

By KONRAD MEIER
NEW YOKK CITY

HYGIENE, as a science, traces the causes of disease to which mankind is exposed in every phase of life. Its practical value lies in the preventing of these causes, through the sanitation of our surroundings and the rational care of body and mind. The gradual improvement of public health and the incident saving of vital energies as the result of true hygienic living would easily make this field of knowledge rank among the most potent factors in the development of races. Unfortunately, its greater possibilities are not yet being realized, for want of application, which is, as yet, too much confined to the professions directly concerned with matters of health. The principles of hygiene must be brought home to the people at large, must grow into and form the habits of our daily life. They should, in fact, be applied in every craft and trade, led by the professions, as, for instance, by architects and engineers, upon whom depends largely the healthfulness of our homes, of a multitude of public utilities, and of the commonwealth as a whole. In architecture and engineering, the problems bearing on health should be approached in a spirit independent of mercenary considerations. They ought to be solved strictly on their merits, with a fair perspective towards hygienic quality in all questions of serviceability, ornamental features and structural needs. Such quality is often necessary to the full realization of the aim, and essential to true artistic value as well as to material success. We can not ignore the laws and lessons of nature in building up the city of enduring beauty.

In crowded industrial and commercial centers, the excessive vitiation of the atmosphere has grown to be an important factor bearing on public health. While a systematic supply of pure air to buildings has long been recognized as a necessity, the state of the outer air has not yet received the attention it deserves, and is too often accepted as a matter beyond control. Nevertheless, an inquiry into the sources of its pollution will readily show that much of it might be prevented. That it ought to be prevented is becoming more apparent as its bearing on prevailing diseases is definitely being established. The movement for better ventilation would also gain through a closer study of the causes of impure air. Abundant literature exists on standards of purity, on temperature and humidity, also on the amount of air to be supplied per capita, but comparatively little effort has been made to trace out and bring to light the less evident and often unsuspected factors of contamination, which indicate, or at least should help to determine, the logical method of relief.

The sanitation of the air is a field which has hardly been recognized as such, at least it is not carried on systematically, with that end in view, and the results of present efforts, on the whole, are distinctly behind the progress made in other lines. Indeed, its failure to meet the aggravated needs of our crowded and growing cities can actually be traced on their vital statistics.

The Bearing of Impure Air on Health

An exceptionally clear exposition of the process of breathing is contained in the short essay, 'Air, and its Relation to Vital Energy,' by Professor S. H. Woodbridge, of the Massachusetts Institute of Technology. The oxidation of organic matter within the human body is likened to the process of combustion in a boiler furnace. This analogy applies to every essential point and shows that the conditions making for efficiency in artificial heat production are also those which bear on vital energy. The intensity of combustion within the human body depends upon the rate of exchange between the carbonic acid contained in the venous blood and the oxygen brought into the lungs, or the rapidity at which the waste products brought in from the system are being diluted. A slight abnormal accumulation of this gas in the air cells of the lungs would check this outward leakage or expulsion of waste products and retard regeneration of the blood, but respiration automatically regulates this function. Exhausted air, with deficiency in oxygen and excess of carbonic acid, to sustain equal force, thus requires increased respiration, an unconscious effort, gradually lapsing as the gathering waste products react upon the blood and through it upon vitality. The weakened light of a candle flame in exhausted room air very aptly illustrates also its effect on human beings.

Exhausted Air.—Recent experiments by Fluegge, the eminent German investigator, seemingly contradict this theory. At least they make it appear that the paucity of oxygen and the simultaneous increase of carbonic acid and other waste products, have no appreciable ill effect on the average adult, but that the depression of spirits, headache and drowsiness felt in crowded, ill-ventilated assembly rooms are principally due to disturbance of the thermal functions of the body through heat and moisture. Since these excesses in temperature and humidity always accompany exhaustion they should certainly be regarded as contributory factors, which help to depress the vital powers according to their prominence. It has been asserted, also, that the human organism has long been used to the frequent breathing of foul air, and will adapt itself to any condition tolerable at all in the long run. This is true to an extent, as to the products of breathing as well as to temperature, but it is more than likely that any immunity from the habit of living in badly used air is gained at the expense of vitality.

Contaminated Air.—As distinguished from 'exhaustion' of air, or shortage of oxygen, with the corresponding increase of carbonic acid and other waste products, the term 'contamination' may be applied to impurities of gaseous and solid nature, aside from the normally unavoidable. This includes, for instance, gases and vapor from industrial sources, also smoke, soot and dust with its attendant bacteria.

The amount of carbonic acid found in air is commonly regarded as a measure of the degree of vitiation, but wherever pollution of the air is likely to occur independent of an increase of combustion or respiration that method of testing the purity naturally is deceptive. Indeed, contamination quite often predominates exhaustion, and should always be considered by itself, as a separate factor, according to the nature of the case. While the effect of exhausted air may have been overestimated, the bearing of contamination on health does not seem to be sufficiently realized. Its claims on vitality are of a different nature. Any admixture of foreign gases may react directly upon the blood. Such poisoning, however, is mostly due to local sources, readily detected and prevented. By far the greater mischief is done by the solid impurities afloat in the air. Although these are normally arrested by the moist, mucous surfaces of nose and throat, they will, under certain conditions, enter the lungs, fill the minute air chambers and lodge there indefinitely. Through life in smoky or dusty surroundings large portions of the lungs become useless in this manner, invite decay and the fatal attacks of bacteria. Dr. Louis Ascher, in publishing the results of his exhaustive investigations on the subject, has shown conclusively that smoky atmosphere encourages diseases of the respiratory organs, materially shortens the life of consumptives and bears distinctly on the mortality of afflicted districts. The charts of distribution of pulmonary tuberculosis in Chicago show indeed the cases to be most frequent near the cluster of railway stations. The appalling contingent of lung patients sent to the Rocky Mountains from our smoky cities of the middle west gives a sad testimony to these facts.

Still greater mischief is done by solid impurities, especially dust, as the carriers of disease germs. True, the best authorities now agree that the presence of microbes in the respiratory organs does not necessarily produce disease, and that the germs must first make their way into the system in order to develop, and find it in poor condition before they can do serious harm. Predisposition, in the form of inflammation combined with lowered vitality, seems therefore necessary to develop the more serious pulmonary diseases. Unfortunately these predisposing ailments are very prevalent and almost unavoidable, to judge only by the numerous traces of mucous sputum displayed on public thoroughfares, mostly witnesses of chronic catarrh. The first irritation is not always caused by exposure to cold, dryness or humidity, but often by soot and dust, or the depressing conditions of indoor and city life generally. As to the effect of these impurities on diseased tissue, we have recently come to authoritative information through the report of the committee on the influence of climate, made before the National Association for the Study and Prevention of Tuberculosis. By analysis of the various factors contributing to a successful cure, it was found that good results may be secured under most widely differing climatic conditions, the benefits of relative humidity, temperature, altitude, etc., being practically dependent upon the patient's general condition or constitution. It has been found, however, that, when other things are equal and the same attention is paid to diet and hygiene, the best results have always been noted where the atmosphere was purest. Indeed the report places 'Abundance and bacteriological and chemical purity of the air' as first among the beneficial influences, while the value of sunshine and the therapeutic effects of coolness, dryness, etc., are placed next in order of importance.

Surprising results seem to have been obtained lately by the outdoor treatment of pneumonia, in which very probably the greater purity of the air is a contributing factor. The success of the fresh-air colony at Seabreeze also confirms the theory that the cure is greatly assisted by the pure sea air, that is, by the absence of dust and bacteria, which irritate, and continually bring renewed infection to the receptive diseased parts. It is for this reason that outdoor life, almost anywhere, is beneficial to lung patients, since they avoid at least some of the multifarious, insidious forms of contamination peculiar to the air in the average dwelling.

All these facts point to the meaning of impure atmosphere in densely populated cities, where the seeds of disease are most abundant, and the field for infection is prepared for it, fertilized, so to speak, by all sorts of conditions and modes of life, more or less beyond one's control. A good crop of pneumonia and kindred diseases seems assured for the winter season, when the tax on vitality is severest, and indoor life in unsanitary quarters supplies the opportunity. This seems almost sufficient to explain the present situation in our large cities, which has brought about the organization of the Pneumonia Commission through the New York Board of Health. In this connection, Dr. Herman M. Biggs, the general medical officer of the board, has stated, that the number of victims claimed yearly by pneumonia increases steadily and alarmingly. In New York City alone during the first six months of 1905 one third the total number of deaths were charged to acute respiratory diseases and pulmonary tuberculosis. During that period the deaths from these causes numbered 14,091. In the corresponding period of the year before they aggregated 10,890.

When we compare the efforts of the sanitary corps in this particular direction with the systematic and thorough work done in checking certain epidemics, we can not fail to note the lack of a comprehensive system in fighting diphtheria, grip, pneumonia and other respiratory diseases, which now claim a majority of victims. The situation seems to be recognized, but is met only to a limited extent. Much good has been accomplished through sanitary inspection, stricter enforcement of the regulations against expectorating in public places, also by exhibits and other educational work, but there are many other possible lines of action which should be taken up as parts of an organized campaign for the sanitation of the air. Since the most promising measures must always be of the preventive order, we should, above all, study the causes which lead to unwholesome atmosphere.

The Causes of Impure Air

Quantities of smoke, vapor, dust and other offensive waste products are constantly discharged into the atmosphere of urban districts. The emanation of all this matter is so rapid that it becomes visible within a few hours whenever the purifying breezes die away, and yet the gathering gloom is not generally recognized as pollution of the air, but rather taken for a change in weather. According to the seasons, the solid particles like soot and dust will cause a haze, or encourage the formation of mist and fog, sometimes, during the winter, depriving a city for days of the life-giving sun.

The sources that contribute to this pollution of urban atmosphere naturally increase with the population, while the dispersal of impure matter by the natural air currents becomes more sluggish and uncertain with the growing areas of urban settlements. The density of population in certain metropolitan districts is easily ten times that of smaller cities. The rate of vitiation of the air through smoke and other waste matter must therefore be at least that much greater. Comparatively speaking, the conditions of health in a crowded community are like those prevailing on board ship. The living space is still smaller than that of the average city dwelling, but the elements contributing to the vitiation are about the same per capita, hence more concentrated and more in evidence. We know that extra labor and care are necessary on a vessel to maintain the air in a tolerable state, quite irrespective of ventilation. In cities, where dwellings and shops are built not only closer together, but are literally piled up on each other, the general contamination is likewise bound to become unwholesome unless special care is taken in disposing of waste matter that may find its way into the air. No doubt more is being done in this direction than in former days, but the rapid concentration of living quarters and industrial shops brings with it new conditions. It should be remembered that it is our pressing duty, and part of that civilization which has built cities for millions, to keep them not only inhabitable, but healthful, wholesome and pure. Elbert Hubbard in the course of his travels once observed that 'The path of civilization is strewed with tin cans.' This certainly insinuates that we have not yet arrived, while tin cans and a multitude of other witnesses of neglect in civic duty are seen along the path.

The Smoke Nuisance.—Smokeless combustion is not only feasible for almost any kind of coal, but more economical if properly attended. The principal difficulty exists in the design of the proper furnace to suit the fuel and to meet the conditions under which it is burned. There ought to be no restriction on the use of bituminous or any other coal. On the other hand, no excuse should be accepted for black smoke from any source within city limits. If not willing or able to suppress it, the offensive industry must be made to move. But all the smaller and innumerable sources of medium, light and invisible smoke should also receive attention. They emit, in reality, by far the largest share of it in the average commercial and residential community, less noticeable because more diluted, but none the less objectionable. The reduction of this smoke is, for practical reasons, beyond control of local health authorities, but it can gradually be eliminated through individual action; that is, by the general concentration of light, heat and power service. The movement in this direction was started long ago with the introduction of central stations for light and power, but it is capable of much greater extension, particularly for heating and power. The bulk of the fuel should be burned at the mine, or at tide-water outside of city limits. Such concentration of combustion for various needs represents a material saving in the total amount of fuel consumed, and, therefore, of the smoke produced. It would incidentally avoid the handling of much coal and ashes and reduce the large amount of exhaust steam now seen pouring away from the numerous individual plants in certain neighborhoods. On still days, these vapors contribute perceptibly to the murkiness of the atmosphere. *The use of steam power for transportation in urban and densely populated suburban districts has long since ceased to be a necessary evil and should have been prohibited years ago.* It is gratifying to state that at last this much-needed economic and sanitary reform seems about to be realized.

Street Dust.—Dust of the streets is one of the principal elements in polluting the atmosphere. It is made up of innumerable substances utterly defying description. To what extent it permeates the air, even in buildings, is proved by a microscopic examination of deposits from furniture, which shows a large percentage of animal refuse, mostly horse offal, ground up by the street traffic. 'Dirt is useful matter in a wrong place,' was one of the lamented Colonel Waring's maxims. He had, indeed, not only succeeded in removing it, but was in a fair way to make it pay for the cost of removal. Sanitation and economy often go hand in hand.

Concerted action is necessary to suppress this nuisance. No one should complain about dust who is not doing his share in preventing it. Each citizen must be his own sanitary officer and each sanitary officer and employee must be made to attend to his duties on public property. Corporations operating public conveyances should also be strictly held up to their duties. A case which illustrates this point is the New York Subway. Dust from the streets, mixed with sputum and sweepings from within, are permitted to accumulate indefinitely on a road-bed of gravel, which can never be thoroughly cleaned. The trains continually stir up some of this accumulation and impart it to the air. *This is an inexcusable offense from a hygienic point of view.* We need only consider that an underground route has not, like a surface railway, the natural assistance of wind, rain and sun in maintaining salubrity, and that it requires extra care and attention to make up for such disadvantage. The drippings of oil will not altogether bind or lay the dust, and the present method of drawing in air through dirty sidewalk gratings can not improve matters in this respect. An easily cleaned surface and effective mechanical means should be provided to keep the road-bed and the entire tunnel 'clean as a hound's tooth.' The stuffy atmosphere often noticed in the subway is largely traceable to these impurities, which are more objectionable than the heat and the exhaustion of the air. The latter, after all, may be regarded as temporary drawbacks, while dust and bacteria inhaled during the shortest transit will cause infection, threatening disease to any one predisposed. Unless built and operated with a reasonable appreciation of hygienic science, subways may at times become a serious menace to public health, especially when grip and similar epidemics are prevailing.

Causes for Impure Air in Buildings.—Among the numerous factors which may contribute to vitiate the air in buildings, some can always be eliminated, while others are unavoidable and should be counteracted by ventilation, in one form or another. Acting on the principle that prevention is better than cure, we should pay attention first to the avoidable sources. Waste matter of any kind is certain to contaminate the air without necessarily being perceptible by odor or by any of the customary methods of testing. Dust and dried-up sputum from the street, brought in by the air or by clothing, unless frequently removed, will permeate carpets and draperies, from where it is continually stirred up, thus filling the air with all sorts of impurities, irritating and disease-bearing. The stuffy atmosphere one notices when entering certain assembly halls and churches is nearly always due to lack of energy or method in cleaning, quite often through inaccessibility in 'dirt corners' or other hygienic fault in the design of buildings.

The combustion of gas and kerosene in living rooms rapidly vitiates the air. Each burner will use up as much oxygen as several persons, besides generating heat, moisture and often sulphurous acid gas, specially injurious to nose and throat. *Stoves or grates for heating or cooking by gas should invariably be connected to a flue to carry off the products of combustion.* Even if used for lighting only, the discharge from lamps becomes very objectionable without ample provision for its escape from the room.

Smoke and vapors are unavoidable wherever cooking is going on, but through immediate and effective removal at the starting point, their spread can be prevented. There is no excuse for any odors invading the living rooms; indeed, if the vapors are properly taken care of, the air in the kitchen itself can be kept reasonably wholesome and pure.

Dust, smoke, gases or hot air from industrial sources which are often allowed to contaminate the air in workshops and laboratories can be classed as avoidable factors, since it is nearly always possible to localize them. Grinding wheels, buffers or other machinery should be equipped for this purpose with devices for mechanical suction to pick up and remove the dust or fumes before they can spread and do harm. Poisonous gases in laboratories should also be removed as soon as generated. Waste heat which would otherwise become annoying should be neutralized by insulation. The design of such arrangements requires special training and experience, but the principles of it can easily be understood and insisted upon by laymen.

The Vitiation of the Air through Heating, Cooling and Ventilating Apparatus.—Every one is familiar with the discomforts of modern heating apparatus. The most frequent complaints are of dryness, disagreeable odors or stuffy atmosphere, sometimes combined with overheating. These conditions are so common that they have almost come to be regarded as unavoidable drawbacks, more or less peculiar to certain methods of heating.

Since the capacity of air to absorb moisture increases with its temperature, heating, by any method, will have a drying effect. In clear cold weather, when the atmosphere out of doors contains little moisture, the relative percentage indoors may drop below a point to which most persons are acclimated. Unless made up by internal sources, some artificial supply of moisture seems desirable in such cases. It is, however, not necessary and not desirable, as is often recommended, to go beyond, or even as far as, making up the deficiency caused by heating, since the human system is used to considerable changes without any real discomfort. Indeed, dry air, *if pure,* is probably more beneficial to normal adults than moist air. The principal reason why the demand for moisture in heated rooms has arisen is the irritating effect of floating dust which has been set in motion by the heating system, directly or indirectly. In the worst form this may be noticed with hot-air heating through floor registers, which invite all sorts of rubbish to fall into the flue, only to be dried and sent up again, often directly into one's nose. Radiators also, especially those with inaccessible surfaces, will gather dust. When cold, it will lay there and molest no more than that on furniture, but as soon as heat is turned on, the tiny drops of moisture, which always cling to these solid particles, will evaporate. Free of this weight, the dust is easily set in motion by the currents of warm air rising from the radiator, as may often be seen by the tell-tale shadows on the wall above. *Heating apparatus thus contaminates the air with dust and bacteria which otherwise would lay undisturbed and out of harm's way.* Moistening of the air will not prevent this to any extent. It increases, in fact, another source of contamination, still too common with modern heating systems—the dry distillation of the organic matter on hot surfaces. This phenomenon has recently been studied by the noted hygienists Professors Esmarch and Nussbaum, who have independently reached the conclusion, that organic dust begins to distil or singe when a radiator reaches a temperature of about 165° F., and that this process is rather encouraged by moisture, probably because the hygroscopic matter clings longer to the heated surfaces and is therefore decomposed before it rises up in the air. *To reduce the vitiating effect of heating apparatus, we must insist on the most accessible and simple styles of radiators,* on which any dust can readily be seen and is apt to be removed, and on ample heating surfaces of moderate temperature which will tend to avoid the decomposition of organic matter.

Overheating by itself must be considered as vitiating the air; at least in so far as it makes it unfit, or less wholesome, according to some noted hygienists who have thoroughly investigated its effect. It seems, at any rate, to give the air a lifeless quality, which soon imparts itself to the victim of our wasteful modes of heating.

Apparatus for artificial moistening, which is now often installed in connection with heating and ventilating systems, aside from the liability of exceeding the desirable humidity, also gives opportunity for contamination of the air supply. Unless the devices are designed on sanitary principles and intelligently attended to, they are very liable to become foul and malodorous, if not unhealthy.

Like the heating of buildings, artificial cooling may also have unwholesome effects. Special provision must be made for drying the air to keep down the relative humidity in the rooms so cooled. In moist and warm weather it would otherwise reach the saturation point. Such a condition is not only uncomfortable, but can become very unhealthy. The science of artificial cooling is as yet very little understood by the average layman and any devices which do not give perfect control over humidity must be cautioned against.

Ventilating apparatus itself may become a source of contamination if improperly designed, operated or maintained. Air filters have been found, for instance, which were intended to arrest the dust, but actually also arrest nearly all the fresh air. Some of these filters can not be cleaned or renewed without spilling the very impurities collected into the air ducts and thence into the rooms. Mechanical ventilating devices too often defeat their usefulness by lack of control over air currents and temperature, which either puts them out of service, or the persons for whose benefit they were intended.

Vitiation through Animal Life.—The last, but not the least, among the sources of vitiation is the presence of animal life or of man. Theoretically, perhaps, this may be called the only unavoidable factor, or the one which must be met by ventilation. The exhalation of carbonic acid in place of the oxygen inhaled reduces the life-giving quality of the air, or its power of regenerating the blood. Exhaled air, moreover, is charged with vapor and organic matter. The substance, called effluvia, which emanates from the surface of the human body is also of organic nature. It is harmless enough when permitted to dry and disperse, but in the moist and warm air of over-crowded rooms it quickly putrefies and becomes obnoxious. It can be recognized by that pungent odor characteristic of a sweltering mass of people. Whatever ill effects may be due to effluvia come through the action of odor on the nerves, rather than through inhaling this comparatively innocuous matter. The excess of heat and moisture produced by an audience as previously mentioned is now regarded as more than a temporary discomfort, quite aside from the danger in subsequent exposure to cold. Exhaled air, effluvia and heat thus combine, in varying proportions, to make room air unfit for breathing. In crowded meeting places they are the principal sources of vitiation, which may practically determine the artificial supply of air, while, for instance, in dwellings, offices and shops with liberal space allowance and plenty of exposure they are often a negligible quantity compared with the sources of contamination.

Suggestions for Relief

The remedy for the unhealthy conditions described naturally lies in systematic sanitation of the air; indoors as well as out-of-doors. The methods of carrying on such work are indicated by the causes themselves, and some remedies have already been suggested. In regard to open air they are practically limited to measures of prevention.

Sanitation.—The New York Board of Health now sends school-children to dispensaries and specialists for deafness and defective eyesight, in the hope of reclaiming them from the dullness consequent to these ills. This unquestionably helps to keep certain contagious diseases under control, and it may be justified on other grounds, but it should not be forgotten that certain unsanitary conditions, to which such diseases can often be traced, barely receive any attention in the sense of an organized campaign for purifying the air. Particular attention should be paid to the suppression of all markets and other nuisances affecting the salubrity of streets and squares surrounding schools and hospitals. The maintenance of public buildings on strict sanitary lines by systematic processes of cleaning, disinfection, repainting and repairing is also too much neglected. The movement for the better housing of the poor, however much has been accomplished, can only be called a beginning. Hundreds of the better sort of tenements are being built, but thousands are needed. If the health board has the right to condemn old rookeries, to order repairs, to pass on workshops in dingy basements and the like, there is much to be done yet on these lines.

The campaign against expectorating, in which Dr. Darlington, the present New York health commissioner, has taken an active part, is most commendable. It certainly reduces the constant danger of infection, but it does not lead far enough toward stopping its causes, the chronic catarrh and other ills largely induced by untidy streets and buildings, public and private.

Sanitary inspection has long been organized in many cities, for certain classes of buildings, but it must include all public conveyances, conveniences, highways and byways in order to be really effective. It should be supplemented by jurisdiction over hygiene in lighting, plumbing, heating and ventilation of new buildings, and in the maintenance of streets, sewers and other public works. This may seem to be a large ground to cover for the average staff of health officers, but it is not altogether a question of men, but one of influence or power of the board over other departments, which should be made to carry out their own work with due regard for hygienic requirements. Sanitation on these lines would be of particular value as an education to the citizens by way of example.

Hints on Ventilation.—The foregoing arguments should have made it clear that ventilation is not the only cure for vitiated air. It should be regarded rather as a supplementary measure, to be used where other means of sanitation can not or will not give sufficient relief. To ventilate buildings with the impure air from city streets, railway cars with smoke from the engines, subway cars with dust-laden air from the tunnel, is naturally inefficient and of questionable benefit. Efficiency in ventilation must come through wider streets and courts, cleaner thoroughfares, the abolition of smoke and dust nuisances, and last, but not least, through the design of buildings, engineering work, public conveyances and their equipment on sanitary lines.

Laws have been in effect in several states which prescribe a fixed amount of fresh air to be supplied per capita in schools and theaters. These laws do not cover the standard of purity, except perhaps as expressed by the carbonic acid test, which does not measure the worst forms of contamination. They do not always define temperature and other qualities essential to secure its benefit to people. Moreover, it is almost hopeless to enforce them in the proper spirit. Discretion might often be in order where natural conditions will help, but can not be conceded while the exact volume of artificial supply is prescribed. The chief benefit of such legislation lies in its educational effect on people. *The urgent need to-day is to bring before the public again and again the most objectionable causes of impure air, especially those of preventable nature,* and to promote sound judgment as to the logical and practical means of relief.

Ventilation can be effected by natural, artificial or mechanical means. Each of these three methods has its field for application. Natural ventilation is incidental to the design and construction of a building. Frame houses are subject to considerable leakage through the shrinking wood-work of walls, windows and doors and through their greater exposure to the air generally. Such ventilation may also be called spontaneous. It is generally sufficient in exposed wooden dwellings, at times even greater than necessary. Brick and stone buildings are also subject to more or less spontaneous ventilaton, which, however, does not always meet the need. In such cases, the general design of the building should be arranged deliberately to encourage a natural ingress and egress of air. For residences and offices not unduly crowded, this may suffice with a fair exposure, but often it should be supplemented by artificial means. This implies that the building must have certain features which induce a decided movement of air, such as shafts leading from kitchen and inside rooms, also fire-place flues and vents from special sources of odor. With such provisions an active removal of foul air may be effected by differences of temperature, increased possibly by waste heat available. The leading idea should be to give the most advantageous direction to the natural currents of air. Systematic supply of fresh air, combined in some form with the heating apparatus, is appropriate in many cases, particularly as it permits some control over the purity, temperature and humidity of the air entering the building.

Mechanical or forced ventilation finds application where the number of people, excess of heat, or other conditions creating unwholesome atmosphere, can not be overcome by any other method. Theaters and crowded assembly halls, class rooms, hospitals, certain laboratories and workshops, hotel kitchens, public smoking and toilet rooms, generally need a rapid renewal of air. The ventilation of such places should be positive, that is, it should not be dependent to any extent upon weather or temporarily favorable conditions. Of course, when subject to spontaneous ventilation, such rooms will require less of the artificial kind. Indeed, it is important always to utilize the natural means at hand, and to omit none of the preventive measures that may help to relieve the situation. *Buildings should be designed with due regard to airing and to avoid, if possible, the necessity for a mechanical system.* The latter should always be considered as a sort of emergency device and reduced to the utmost simplicity consistent with the need. Of course, simplicity must not be secured at the expense of quality or efficiency. The latter depends mostly upon the purity, perfect distribution and the control over the temperature of the air supply. Moderate volumes, well applied, are better and more economical than large quantities indifferently, indiscriminately, almost criminally introduced. When designed and equipped on the right principles, buildings will be less dependent upon the uncertainties of complex machinery, incompetence or indifference of operators, parsimoniousness of owners, and all those contigencies which so often have turned a well-intentioned, but too complicated, apparatus into a dead letter, a lot of junk, or even a nuisance and a menace to health, instead of a means of relief. The undesirability of mechanical devices increases rapidly with their complexity and age. Deterioration is bound to set in. The simplest means to accomplish the end is not only the most economical, but it is the best guarantee for successful operation in the long run.

Building Reform.—The extreme utilization of space which is the common tendency in much of our urban architecture has passed the sanitary danger line. There are too many investors, or speculators, who do not care whether a structure is fit for habitation. Unfortunately, architects do not always realize the meaning of the demands put upon them, and that those exaggerated proportions, growing out of the fight for light and air, will make sanitation more difficult and are unfair to the neighbor. *When building on a plot of ground, any adjoining property should be given an equal chance for vertical expansion,* giving leave to any one to do unto you the same, with profit. Some of the flagrant encroachments lately seen upon other men's right to nature's freedom have really been nothing short of criminal. The limitation of the sky scraper is really but a question of fair dealing with one's neighbor.

The campaign for tenement-house reform, lately rewarded by splendid results, has been a step in the right direction. Its bearing on the building laws is one of the most important benefits. The provisions calling for greater court area and other features calculated to relieve crowding and to assist natural ventilation should be made even more sweeping *and extended to all classes of buildings.*

To improve the housing, for rich and poor, and to make a city more healthful generally, we must aim to relieve this excessive crowding. A good beginning has been made by the fight for small parks. More of these breathing spots are needed, sorely needed. Healthy play-room for the children of those unbroken rows of flats is hard to obtain, but it must be secured, if only to break up the monotony of brick and stone and relieve it with some wholesome vegetation, cooling, purifying bits of nature. Even if limited to a single block, small parks could be utilized for schools, as is done frequently in smaller towns. This would be really the ideal way of securing their full benefit, the children profiting in the day, adults in the evening, and the neighborhood all the time. The plan of locating public buildings and schools on open squares or parks may be luxury in country towns, *but it is a necessity in large cities from a sanitary point of view.* This idea, once recognized and rooted, might be the wedge for a new method of securing sites, of making the school the excuse, or rather the necessity, for another small park. It should at once be adopted in outlying districts where space is less expensive. The finest sites set apart for public institutions have never been found too good and always will prove the best investment of public funds from every point of view. It can not but influence the private owner to plan and build with a broader purpose than the immediate commercial gain, which has demoralized the arts and crafts, the architecture of the day, and will be a testimony to future generations of the materialism of our age.

To bring daylight into the dwellings of the ignorant masses is to educate them and to banish dirt, filth and disease. More light incidentally brings more air and purer air. But there is need for sanitary reform also in the dwellings of the rich. It should begin with more sensible building plans, a return to simplicity in design and construction with a view to inducing salubrity as the first principle of hygiene. It is not so much the quantity of air that is to be considered, but rather the quality. Let us have not only more air, but purer air, as from the open country or the sea. Sanitation of the air is a lesson taught by nature. Civilization must apply it for humanity, for the wholesome enjoyment of life to all.

THE JEWS: A STUDY OF RACE AND ENVIRONMENT. IV.

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Mortality

THE bulk of the Jewish population in the orient and eastern Europe lives mostly in the oldest and most congested parts of cities amid squalid and unsanitary surroundings, where the mortality rates are, by general experience, known to be excessive. Physically, the eastern European Jews appear to be weak, anemic and decrepit when compared with the christian population, and in addition they are mainly engaged in indoor occupations. These peculiarities would lead one to expect *a priori* that the mortality rates among them would be much higher than among other people, who live mostly under better hygienic and sanitary conditions, have a large proportion of agriculturists who live in the open country, and are engaged in outdoor occupations, and to all outward appearances are more robust and healthy. It is a remarkable fact, however, that the contrary is true. The figures in the appended table, giving the results of most recent official censuses

Country.	Year.	Annual Mortality per 1000.		Mortality of Christians 100, Jews —
		Jews.	Christians.	
Algeria	1901	20.58	23.14	88.93
Roumania	1902	20.02	29.06	68.54
Cracow (Galicia)	1895–1900	19.70	35.90	64.00
Warsaw (Poland)	1901	18.22	24.59	74.09
European Russia	1897	17.82	36.49	48.81
Hungary	1903	17.29	27.24	63.47
Austria	1901	17.26	25.18	65.93
Hesse	1901–1904	14.80	19.10	77.48
Prussia	1904	14.22	20.44	69.57
Berlin	1904	13.32	17.12	77.80
Prague	1901	13.26	20.02	66.23
Budapest	1903	13.20	19.00	69.47
Amsterdam	1900	12.27	17.44	70.36
Bavaria	1902	12.11	23.08	52.47

in various countries, show that the rates are much lower among the Jews than among other Europeans. Only in Algeria and Roumania do the rates exceed twenty per 1,000 population, but in all the other mentioned countries the annual rates are less than twenty: In Poland (Cracow and Warsaw) it is between 18 and 19; in European Russia, Hungary and Austria, 17; in Prussia, 14; in the capitals of Prussia, Bohemia and Hungary, only 13; and in Amsterdam and Bavaria the low rates are almost unprecedented, only 12 per 1,000. A yet lower mortality rate was found among 10,618 Jewish families, including 60,630 persons living in the United States December 31, 1889. In the figures published in Census Bulletin No. 19 (Washington, December 30, 1890) it appears that the death rate was only 7.11 per 1,000, which is but 'little more than half the annual death rate among other persons of the same social class and conditions living in this country.'

The low death rates of the Jews are more strikingly demonstrated when compared with the mortality of the christian population of the countries in which they live. This is done in the fourth column of figures in the table; the mortality of the non-Jewish population is taken as 100. It is seen that the Jewish death rate in Algeria is but 89 per cent. of the mortality of the other Europeans in that country; in Bavaria it is a little over, and in European Russia even less than, fifty per cent. of the christian mortality. In other words, the death rates of the Jews are from eleven to fifty per cent. less than those of the christians.

These favorable mortality rates of the Jews are not a recent phenomenon. At all times when statistics on the subject were compiled it was found to be the case. The censuses of Prussia give some very interesting figures in this connection. The rates since 1820 were as follows:

Average Annual Mortality per 1,000

Year	Jews	Christians
1820–66	20.40	
1878–82	17.53	25.23
1888–92	15.71	23.26
1893–97	14.73	21.84
1900	14.96	21.70
1904	14.22	20.44

It is thus seen that the mortality in Prussia has been sinking in recent years among both Jews and christians, decreasing by about twenty per cent. since 1878 in both groups. This is of course to be attributed to advancement in economic, social, hygienic and sanitary conditions. But it is remarkable that there is no change in the ratio of Jewish to the christian mortality; it was in 1878 sixty-nine per cent. of the mortality of the christian and remained the same in 1904. Hungary is another country where reliable statistics are available for fifteen years. The figures are as follows:

Deaths per 1,000

Year	Jews	Christians
1891–95	19.07	33.12
1896–1900	16.87	27.62
1901	16.95	25.94
1902	17.42	27.89
1903	17.29	27.24

Here it is to be noted that the mortality of the Jews was in 1891 more favorable than in 1903. The decrease during the last fifteen years was more marked among the christians: In 1891 the Jewish mortality was 57.58 per cent. of the christian mortality, while in 1903 it was 63.47 per cent., which indicates that they are approaching the mortality rates of their non-Jewish neighbors. Data for Warsaw, Poland, show the same process: In 1882 the mortality was, Jews 24.48, general population 32.34; in 1891, Jews 20.27, general population 23.05; 1896, Jews 20.42, general population 23.54; in 1901, Jews 18.22, general population 21.22. All this indicates that in recent years the differences in the mortality between Jews and christians are being obliterated.

Death is a biological phenomenon, and can not be influenced by purely ethical or metaphysical factors, such as, for instance, religion, when Jews are compared with christians. Differences in religion are consequently not sufficient to explain the differences in the mortality rates between Jews and non-Jews. Nor can racial affinities explain completely the low mortality of the Jews, because physically the Jews bear a striking resemblance to the non-Jewish races and peoples among whom they live, and also because the differences in the rates are too large in each country to admit racial uniformity. A study of differences in social and economic conditions is more fruitful of results. Thus, in Budapest the death rate of the Jews was only 69.47 per cent. of that of the christians. But, as is aptly pointed out by Körösi, according to the census of 1891, out of every 1,000 inhabitants there were common laborers, among the catholics 118, among the Lutherans 125, among the Jews only 67; domestic servants were found, among 1,000 catholics 95, Lutherans 98, and among the Jews only 17; merchants were found, among 1,000 catholics 20, Lutherans 36, while among the Jews the figure was 131. These social differences are of sufficient importance to greatly influence the death rates and to account for the favorable showing made by the Jews. As is well known, certain occupations are more deadly than others. When to this are added other social factors which differentiate the Jews from the christians, such as the rarity of alcoholism and illegitimacy among the former, and the proverbial care bestowed by them on their offspring, thus contributing to a low infant mortality, the effects of the social factors become apparent.

Infant Mortality

All this is depicted in a striking manner when infantile mortality among Jews is considered. It appears, namely, from all available data that the Jews do not have the advantage over others when deaths of adults, particularly persons over fifty, are compared. It is only during infancy and childhood that fewer deaths occur among them. In Prussia, where the mortality rates are classified in the census reports according to the age of the individual whether he is less than or over fifteen years old, we find that the mortality of the young is less than one half that of the christians. In 1904 48.89 per cent. of all the deaths among christians in that country occurred in individuals less than fifteen years of age, while among the Jews only 19.78 per cent. of all deaths were in persons of these ages. In Berlin it was in 1904, christians 42.05 and Jews 20.28, also less than one half among the Jews. In Amsterdam the deaths recorded in 1900 were distributed by ages as follows:

Age	Christians	Jews
—1	25.23 per cent.	18.76 per cent.
1–13	15.68 per cent.	11.72 per cent.
13–64	33.58 per cent.	33.38 per cent.
64 +	25.51 per cent.	36.14 per cent.

Here also the mortality during infancy and childhood was smaller among the Jews than among the christians; between the ages of 13 to 64 it was equal among both classes, while among the old it was more frequent among the Jews. The same condition has been found in Hungary, where the mortality of children below seven years of age is 49.5 per cent. among the christian population, and only 43.69 per cent. among the Jews.

Objections may be raised against this method of calculating the mortality of children, because it must first be ascertained whether the distribution of the population by age classes is the same in both groups. This is particularly the case with the Jews, whose birth rates are lower than those of christians. A smaller number of births means a smaller number of infants, and consequently a smaller number of deaths. The best way to compare the mortality of Jews and christians is to calculate the proportion of deaths per 1,000 persons at each age period, *i. e.*, to ascertain the death rates at each age in both classes, Jews and christians. But this is difficult because there are no available data published in census reports. The exact infantile mortality is, however, easily ascertained by finding the ratio of deaths of infants below one year old to the number of births in a given year (excluding still-births). In the following table are given some figures about the infant mortality in some European countries:

Deaths of Infants per 1,000 Births

Country	Jews	Christians
Amsterdam (1900)	92.77	139.56
European Russia (1897)	150.80	274.30
Cracow (1894–97)	155.47	170.84
Hungary (1902)	95.20	164.60

Here also a lower infant mortality is seen among the Jews. Of 1,000 Jewish children born among the Jews in Amsterdam during 1900, 907 survived the first year, while among the christians in that city only 861 survived; in Russia the figures stand, Jews 849, christians 726; and in Cracow, Jews 845 and christians 829. This has a great bearing on the expectation of life of the Jews. According to the calculations presented in Census Bulletin No. 19, 1890, the expectation of life of the Jews is much more favorable than that of the christian population of the United States. Assuming 100,000 Jewish individuals to have been born on the same day (among which there would probably be 50,684 males and 49,316 females), 45,680 males and 44,995 females will survive the first year; 41,731 males and 42,326 females will survive the fifth year, etc. At the end of about 71 years one half of them will be dead. Taking the data for Massachusetts for 1878–82, of 100,000 American infants born (among which there would probably be 51,253 males and 48,747 females) only 41,986 males and 41,310 females would survive the first year; 36,727 males and 36,361 females would survive the fifth year; and half of them would be dead at the end of about 47 years.

While these figures are open to criticism because, as has been pointed out by Hoffman, the method adopted for the calculation of the life-tables is not stated in detail, still it may be stated without any hesitation that the longevity of the Jews in the United States and Europe is superior to that of the non-Jewish population. There is also no doubt that this superiority is mainly due to the lower mortality during infancy and childhood. It is doubtful whether there are any differences in mortality rates during adolescence and middle life between Jews and christians. Among persons of advanced age, over fifty, the rates are higher among the Jews, simply because a larger number reach that age.

The lower mortality of Jewish infants is not due to any special inherent vitality, but finds its explanation in certain social causes: Jewesses in eastern Europe almost invariably nurse their infants at the breast, and it is rare to find among them an infant brought up on artificial feeding. The mortality of breast-fed children is much below that of hand-fed. Jewish mothers only rarely go to work after marriage, and can therefore bestow all possible care on their infants, which can not be said to be invariably true among the poorer classes of population in eastern Europe and America. In western Europe the Jews are economically on a higher plane than the general population, and when infant mortality is discussed it must be recalled that it is much smaller among the well-to-do than among the poor. The Jews should be compared with the wealthier classes of western Europe and not with the general population. To these social factors there must also be added the fact that the birth rates of the Jews are lower than those among the christians. A high mortality can not be expected when fewer children are born. In fact, in Russia, where the birth rate of the Jews is high (compared with conditions among western European Jews), the infant mortality is also higher, though not so high as the mortality of the Greek orthodox, whose birth rates are the highest in Europe.

Arthur Ruppin, who has studied the problem thoroughly, insists that the superiority of the expectation of life of the Jews is mainly due to the higher infant mortality among christians, which drags down the average duration of life. "To use a coarse example: The expectation of life of a christian child on the day of its birth is, roughly stated, about forty years, as against sixty years of the Jewish child; at the tenth birthday the probable duration of life of the christian child is fifty-five, while that of the Jewish child is sixty-five; and at the twentieth birthday the probable duration of life is, for both, seventy years, *i. e.,* the expectation of life of the christian is equal to that of the Jew as soon as the christian has passed his years of infancy and childhood, and reached adolescence."

"The best illustration," Ruppin goes on to say, "of this condition, is perhaps to be seen when we take definite statistical data of a given city, say Budapest, Hungary. The mortality during 1902 was 14.17 per 1,000 among the Jews, and 21.81 among the christians. The Jews were favored by the following factors:

1. *A Low Infantile Mortality.*—The proportion of death of infants under one year was during that year 9.52 per cent. of all the births from Jewish mothers and 16.46 per cent. of all the births from christian mothers. If the infánt mortality was as high among the Jews as among the christians the number of Jews who died during that year would have been larger by 320, and through that the mortality would have been increased by 1.89, *i. e.,* the death rate would have been 16.06 instead of 14.17.

2. *The Lower Birth Rate of the Jews.*—The birth rate per 1,000 population was, namely, 27.29 among the Jews and 32.74 among the christians. If the Jews had relatively as many births as the christians had, the mortality rate, on the basis of the Jewish infant mortality just determined above, would have been larger by 0.48 per 1,000; their general death rate would have been increased to 16.54 from 16.06.

3. *The Smaller Mortality of Children under Ten Years of Age (excepting Infants under One Year).*—The proportion of deaths of children between one and ten years old was 2.15 per 1,000 among the Jews and 3.73 among the christians. If the Jewish mortality at these ages were as high as that of the christians, 266 more Jews would have died during that year, and the general mortality rates would have increased by 1.57 per 1,000, or instead of 16.54 it would have been 18.11.

In this manner one half of the difference in death rates between Jews and christians in Budapest is wiped out. It stands now as 18.11 for Jews, and 21.81 for christians. The remaining difference in the rates of 3.7 per 1,000 in favor of the Jews, can also be accounted for by other social factors, and no special physiological tenacity of life of the Jews need be considered as the cause. One has only to recall that alcoholism is very rare among the Jews, and that the Sabbath is a day of rest among the orthodox Jews in eastern Europe, and not of drink and dissipation, to find a reason for greater immunity to certain diseases, and to a lesser liability to accidental death. Their occupations also are mainly of the kind in which violent or accidental deaths are not of frequent occurrence. There are, relatively, very few Jews engaged in shipping, mining and dangerous trades generally. The deleterious effects of the indoor occupations in which the Jews are largely employed are mostly manifesting themselves in the anemia and poor physique which are characteristic of them. But, on the other hand, they are rarely exposed to the inclemencies of the weather, and thus acute articular rheumatism, pneumonia, etc., are less often a cause of death among them than among others. In fact, diseases of the respiratory organs, including tuberculosis, have been observed to be less commonly a cause of death among the Jews in Russia, Hungary, Austria, England and America.[1] Their partial immunity to consumption is astonishing, considering that they are mostly engaged at indoor occupations, working long hours in unhealthy sweatshops, and living in the most congested parts of the cities. Perhaps a good explanation may be found in the confined Ghetto life in which they have been compelled to live for centuries, and which has adapted their organism to indoor life much better than other civilized peoples, who have a large proportion of agriculturists and outdoor workers. During the long years of Ghetto life most of those whose organism could not adapt itself to the confined atmosphere succumbed and were thus eliminated. It is a general observation that races that are not adapted to indoor life quickly succumb to consumption as soon as they attempt to live in modern dwellings. Among the uncultured 'blanket' Indians of our western plains, and among the Indians of Peru, the Khirgiz Tartars and other savage tribes of Africa and Australia, all of which live outdoors, the disease is almost unknown. But as soon as the same people are taken to modern cities, they can not stand it, but soon contract various diseases common in large cities, particularly tuberculosis. They have not had the opportunity to slowly adapt themselves to an indoor existence, as was the case with the Jews.

Suicide

That purely social factors are the underlying cause of the low mortality rates of the Jews, and that with changes in their social conditions there occur also changes in the death rates, are well illustrated by the frequency of suicide among them. Statistics collected by Morselli ('Suicide,' p. 122) show that during the third quarter of the last century Jews only rarely committed suicide. He attributes it partly to racial, and partly to religious influences, and maintains that individuals fervently devoted to religion, especially women (nuns and

[1] See 'The Relative Infrequency of Tuberculosis among Jews,' by the author, in *American Medicine*, November 2, 1901.

lay sisters) furnish very few suicides. A study of more recent statistics about the Jews confirms this view. In eastern Europe and the orient, where they are ardently devoted to their religion, a Jewish suicide is very rare; in some cities in Russia or Galicia, with over 20,000 Jews, more than ten years often pass without a Jew taking his own life. During the first half of the last century, when the social and economic condition of the Jews in western Europe was not much superior to that of their eastern European coreligionists of to-day, self-destruction was also rare among them. With the decline of the intensity of religious belief which is characteristic of the contemporaneous Jews in western Europe and America an adoption of the habits and customs of the christian population has been noted, among which suicide may be mentioned as a social fact important for study.

In eastern Europe suicide is even to-day less frequent among the Jewish than among the christian population. In Cracow, for instance, one per cent. of all the deaths during 1895–1900 was self-inflicted among the christians, as against only 0.4 per cent. among the Jews; in Budapest, Hungary, the rates in 1902 were as follows:

Number of Suicides per 1,000 Population

	Christians	Jews
Men	6.79	4.61
Women	2.35	1.00
Total	4.44	2.88

Suicide is here less frequent among the Jews than among others. But proceeding to western Europe, where the Jews are affected by what Morselli characterizes as the 'universal and complex influence to which we give the name civilization,' the proportion of suicides is at present much larger among the Jews than among christians, although but fifty years ago it was uncommon. Thus in Würtemberg during 1846–60 the rate was on the average annually among protestants 113.5, among catholics 77.9, and among Jews only 65.6 per 1,000,000 population. During 1898–1902 the rates increased to 252 among the Jews and to only 162.7 among the christians. In Bavaria the suicide rates were during 1844–56, Jews 105.9, protestants 135.4 and catholics 49.1 per 1,000,000. Since 1870 a steady increase was noted as follows:

Number of Suicides per 1,000,000 Population

	Catholics	Protestants	Jews
1870–79	73.5	194.6	115.3
1880–89	95.3	221.7	185.8
1890–99	92.7	210.2	212.4

The increase in the rates of self-destruction among the Jews has thus been so pronounced within the thirty years since 1870 that it is now much higher than among the christian population of Bavaria. The greatest increase has, however, been observed in Prussia. During

1849–55 it was rare among them, only 46.4 per million Jews, as against 49.6 among catholics, and 159.9 among protestants. It so increased in frequency that during 1869–72 it was, Jews 96, catholics 69 and protestants 187; and the increase during the following years was so severe that the Jews outstripped the christians during 1892–1901.

RATES OF SUICIDE PER 1,000,000 POPULATION

	Men	Women
Jews	370.4	124.1
Christians	321.5	81.1

All these figures show conclusively that the rates of suicide among the Jews are not at all influenced by ethnic factors. The social environment is solely responsible for the infrequency of self-destruction among the Jews in eastern Europe, where they live in strict adherence to their faith and traditions; while in western Europe, where they comingle with their christian neighbors, adopting their habits and customs, the rates of suicide increase. Considering that there is a lesser number of children among the Jews, and that suicide is rare among the young, and that they are mostly town dwellers, engaged in mercantile and financial pursuits, there is good reason for the higher rates among them than among others. Further proof of the influence of environment is adduced by the fact that with a change of environment there is also a perceptible change in the suicide rates. The Jewish immigrants in New York city are much given to self-destruction, although in their native homes suicide is very rare. There are no available statistics as to the exact annual number of Jewish suicides in New York city, but an inquiry by Mr. John Paley, editor of a Yiddish daily, elicited the following information: "About fifteen years ago suicide was uncommon among the immigrant Jews, so much so that I always gave each case reported a prominent place in my paper. To-day conditions have changed. There are so many cases of Jewish suicides that unless it is a prominent person, or there are special news features connected with the case, I do not at all mention it in the columns of my daily." He estimates that there are six Jewish suicides on the average weekly in New York City. If this figure is near the truth, and I am inclined to believe it is, then the suicide rate among the Jews in New York is appalling. The aversion to self-destruction of the eastern European Jew is thus seen not to be racial. As soon as he is brought face to face with a more complex life in New York City, as soon as his devotion to his religion is more or less dwindling, any serious reverse in life is liable to discourage him to the extent of causing him to terminate his existence.

IV. *Natural Increase of Population*

From the preceding studies it was evident that the birth, marriage and death rates were everywhere in Europe lower among the Jews than among their non-Jewish neighbors. It is of importance now to inquire what are the effects of these low rates on the increase of the Jewish population. Population increases, as is well known, by the excess of the number of births over deaths, and it is important to inquire whether the small birth rates of the Jews are everywhere compensated by the low death rates, or whether even their low mortality is insufficient to leave a substantial surplus because the number of births is so small as to be insufficient to replace those lost annually by deaths.

In general terms it can be stated that there are two ways by which a population may replace its losses by deaths: First, by a high birth rate much in excess of the death rate. This is usually the rule in communities in a low state of culture, among agricultural classes, and also among the poorer and laboring classes in European and American industrial centers. The death rate, especially the infant mortality, is very high, but this is compensated by early marriages, and a substantial prolificacy. On the whole, the average duration of life is, in such communities, comparatively short; the population is being renewed at frequent intervals.

Communities in a higher state of culture, on the other hand, have generally lower birth, marriage and death rates, particularly the infant mortality is more favorable. It requires a longer period of time for such a community to renew its population, because the average duration of life is superior. This is observed generally among the upper ten thousand of modern civilized states, particularly in large cities. From a sociological and economic standpoint this method of perpetuation of the population, if kept within certain limits, has its advantages over the former method. To use Spencer's terminology, it decreases the expenditure on genesis, leaving sufficient for individual evolution. In other words, the smaller the number of children born has as a concomitant a smaller infant mortality, and also gives the parents an opportunity to raise their offspring on a more desirable standard.

A glance at the figures brought together in the preceding studies shows that the Jews, judged by the social and economic environment in which we found them, can be placed in either one of the mentioned classes of fertility. To begin with the natural increase, *i. e.*, the annual excess of births over deaths per 1,000 population, it is found that there are great differences between eastern and western European Jews.

Country.	Excess of Births Over Deaths.		Country.	Excess of Births Over Deaths.	
	Jews.	Christians.		Jews.	Christians.
Algeria (1901)	24.09	9.43	Prague (1901)	2.59	11.29
Cracow (1899)	17.70	1.30	Berlin (1904)	3.70	10.24
European Russia (1897)	17.61	16.87	Prussia (1904)	4.49	16.49
Austria (1901)	16.63	11.83	Bavaria (1900)	4.60	12.60
Hungary (1903)	14.90	10.68	Hesse (1901–1904)	4.70	14.90
Roumania (1902)	12.34	13.80			

In the former the excess is large, while in the latter it is small. This is seen from the table given above.

In Algeria, the only oriental country where vital statistics of the Jews are published, the natural increase is very great. The social conditions of the native Jews in that country are purely oriental. Early marriages are the rule, and celibacy almost unknown. This brings about a high rate of fertility; their birth rate was 44.67 per 1,000, with a correspondingly high mortality rate of 20.58. But after all the excess of births over deaths is large, reaching annually 24.09 per 1,000. In European Russia, where social conditions of the Jews are more occidental, the excess of births is smaller, only 17.61; in Austria, 16.63; in Hungary, 14.90, and in Roumania, 12.34. All these eastern European Jews show rates of natural increase characteristic of eastern people. Proceeding to western Europe we find a different condition of affairs. The rates of proliferation are low, owing to the low marriage and birth rates; even their favorable mortality rates are insufficient to leave a substantial excess of births over deaths. Thus in Bavaria the natural increase was during 1900 only 4.60, while among the non-Jewish population it was nearly three times as large, 12.6; in Prussia the natural increase was in 1904, Jews 4.49, and christians 16.4; in cities it is even lower, only 3.70 in Berlin (10.24 among christians) and in Prague 2.59 (11.29 among christians). The influence of social and economic conditions on the natural increase of the Jews is well displayed in the various provinces of the Austrian Empire. In Galicia, where the majority of the Jews live in poverty and want, and are rigidly devoted to their religion, the natural increase was during 100, 17.92 per 1,000 (christians, 16.61); in Bukowina, where conditions are about the same, it was 12.66 (christians,15.83); but in Lower Austria where their social, intellectual and economic conditions are much superior, it was only 7.69, while in Bohemia, where the majority of the Jews are well-to-do and are socially comparable with the western European Jews, the natural increase is very low, lower even than in Berlin, only 1.35 per 1,000 (christians, 10.76). There are good reasons to believe that in Italy, France, England and the United States, the same conditions prevail among the native Jews.

These conditions are only a recent phenomenon among the Jews in western Europe. During the first half of the nineteenth century the excess of births over deaths was equal, and even superior to that of the christians. In Prussia, for instance, the average annual birth rate during 1822–40 was 35.46; the death rate, 21.44; leaving an excess of births over deaths of 14.02 per 1,000, as against only 10.40 among the christian population (births 40.01 and deaths 29.61). This excess began to sink gradually but regularly, as can be seen from the following figures:

EXCESS OF BIRTHS OVER DEATHS

	Jews	Christians
1885	10.33	12.29
1890	7.64	12.58
1895	6.66	15.12
1900	4.52	14.57
1904	4.49	16.49

Similar conditions are observed in Bavaria, where the natural increase was larger among the Jews than among the christians in 1876, when a decline began to be noted among both groups, but with a much greater severity among the Jews than among the christians.

	Jews	Christians
1876	15.8	14.1
1880	12.9	10.8
1885	9.9	10.0
1890	6.0	8.8
1895	4.8	12.4
1900	4.6	12.6

The excess of births over deaths among the Jews has thus dwindled to less than one third in Prussia since 1822, and in Bavaria to a little over one third since 1876. This decline in the natural increase of the Jews is not only characteristic of western European Jews, but is also beginning to be noted in eastern Europe. In Hungary, where the rate was among the non-Jewish population only 9.69 during 1891–95, and with slight fluctuations rose to 10.68 in 1903, the tendency among the Jews was decidedly in the opposite direction. It was 17.79 during 1891–1895, and sank to 16.07 in 1901 and even to 14.90 in 1903. The same conditions are observed among Jews in other European countries.

V. *Summary and Conclusions*

The demographic facts presented in the preceding studies lead to but one generalization: The birth, marriage and death rates of the Jews may be taken as an index of their social, economic and intellectual conditions. Wherever they are isolated by hostile legislation, compelled to live apart from the general population, confined in Ghettos, thus deprived of every opportunity to enter into intimate social intercourse with christians; wherever, largely as a result of this isolation, they are on a low economic and intellectual standard, their birth and marriage rates are high, their death rates, particularly the infant mortality, correspondingly high, and practically no intermarriage with christians takes place. Hostile legislation against the Jews is shown, by the evidence presented above, to utterly fail in its aims. Repression of the Jews in countries like Russia has mainly one object in view: To make their life so miserable and unbearable as to induce them to adopt christianity, which removes all disabilities. How far this policy fails in its aims can be seen from the fact that conversions of Jews to christianity are comparatively rare in Russia and Roumania, while, in common with all others who are on a low social and economic level, their natural increase, *i. e.*, the excess of births over deaths is enormous among them. They increase in number in spite of the attempt to check them. This is substantiated by the statistical evidence gathered from the censuses of Russia, Roumania, Poland, Galicia, etc.

On the other hand, in western Europe, in Germany, Italy, France, England and in America, where the Jews are enjoying civil liberty on an equal basis with the general population, and where they are, as a result, on a superior plane socially, intellectually and economically, their birth and marriage rates are so low, that even with phenomenally low death rates there is left a very small excess of births over deaths, in fact they show a striking retrogression and decadence. This decadence is by no means accidental, but can be traced as due to the remarkable development they have been undergoing during the last seventy-five years, and also to the social intercourse with gentiles which in addition also brings about mixed marriages. The children born to these mixed couples are lost to the Jews, less than twenty-five per cent., and there is good reason to believe that hardly more than ten per cent. remain Jews, while the rest is net gain to christianity. On the whole, the native Jews in western Europe and America are being decimated by a low birth rate, and absorbed by intermarriage with christians. Any increase in their number is due to immigration from eastern Europe.

The demographic facts presented by the Jews may also be taken as an index of their religious status. In the orient and in eastern Europe, where the devotion to their faith is intense, they have high birth rates, early marriages, substantial excess of births over deaths, and no intermarriages with christians occur. In western Europe and in America conditions are different and go hand in hand with an evident lessened intensity of faith, often amounting to religious indifference. In fact, the cruel persecutions and massacres to which they were exposed during the last two thousand years have not robbed the Jews of as large a proportion of adherents as modern emancipation with its concomitant adaptation of the habits and customs of modern civilized life. To take Russia as an example. There the Jews are oppressed mainly with one aim in view: to gain them for the Greek orthodox church. As soon as he adopts christianity, the Jew, besides receiving a bonus of thirty silver roubles, is also given all the rights enjoyed by the christian population. But notwithstanding all these tempting advantages offered, less than 90,000 Jews were converted during the nineteenth century. In contrast with this may be taken Prussia, where the number of Jews is only 392,322 (1900) as against about 5,500,000 in

Russia. Here, according to J. de la Roi, as many as 13,128 Jews have been directly converted to christianity during the nineteenth century, and since mixed marriages were legalized in 1875, 10,160 Jews married christians; in Russia no such marriages have taken place, except of those who adopted christianity and are included among the converts. In Russia the birth rate was 35.43 in 1897, not much lower than in the beginning of the last century. On the other hand, in Prussia the rates were high in 1822–40—35.46—but kept on sinking since their emancipation, reaching 18.71 in 1904. In other words, if the Jews in Prussia had remained in their original civil condition, unaffected by modern conditions of life, they would have maintained their birth rates as the Jews in Russia, and the number of children born during 1904 would have been about 13,000 instead of 6,913, as was the case. During the thirty years, 1875–1904, there occurred altogether 267,775 births by Jewish mothers in Prussia. If they had maintained their birth rates at 35 per 1,000, the number born would have been about 385,000 during that period. The decline in fertility has consequently caused a loss of 117,000 to the Jews, and if to this are added the large number of conversions and of mixed marriages, which have taken place in that country during these thirty years, it is evident that the total loss sustained by Judaism was larger in Prussia where there are less than 400,000 Jews, than among the 5,500,000 Jews in Russia during the entire nineteenth century.

The results of these conditions are seen when the relative number of Jews in Germany is considered. In 1861 there were 138 Jews to 10,000 christians; in 1900 the number sank to 114, and the last census taken in 1905 shows another decrease—there are only 109.8 Jews to 10,000 christians. The same has been the case with the Jews in other German provinces, excepting Saxony:

NUMBER OF JEWS PER 10,000 CHRISTIANS

	1870	1900
Germany	125	104
Prussia	133	114
Würtemberg	67	55
Bavaria	104	89
Baden	176	140
Hessen	297	219
Saxony	13	30

Although there was a large emigration of Germans who left for America and for German colonies, still there was an enormous increase of population in that country. In contrast with this increase are the Jews in that country: although very few emigrated within the last thirty years, and many Jews from other countries have immigrated to Germany, still they have not kept pace with the general increase of population, and in fact show a relative decrease in number. And judging by the fact that the birth and marriage rates keep on decreasing, while the mixed marriages and conversions to christianity keep on increasing in number, as was shown in the preceding articles, the future of Judaism in Germany is, to put it mildly, not very bright. The same process of decadence is observed among the Jews in Italy, France, England, America, etc., in varying degrees of intensity. If immigration of Jews from eastern Europe should for some reason cease, the number of native Jews in these countries would dwindle away at a rate appalling to those who have the interests of their faith at heart. In the United States the original Jewish settlers, the Spanish and Portuguese Jews of the seventeenth, eighteenth and the first half of the nineteenth centuries who refrained from intermarriage with their German and Polish coreligionists, have practically disappeared; very few of them have been left. The Jews are thus paying a high price for their liberty and equality—self-effacement.

Another important conclusion we arrive at while studying the above facts and figures is that most of the demographic phenomena are not rooted in ethnic causes. The high rates of proliferation, the exclusiveness of the Jews manifesting itself in part by endogamy, the alleged excessive proportion of male births, the rates of suicide, etc., were all attributed to racial influences, to 'Semitic' characteristics. This opinion has its origin in the observations on Jews made during the eighteenth and first half of the nineteenth centuries, when the Jews all over Europe were a homogeneous social mass, all to the same extent abused, persecuted and confined in Ghettos. Uniformity of social conditions brought about uniform demographic phenomena, which were considered racial traits. But the emancipation of the Jews in western European countries, releasing them from isolation, bringing them into intimate contact with their non-Jewish neighbors, has completely transformed them. Racial traits are not to be obliterated by a change of *milieu* during a comparatively short period of fifty or one hundred years, nor do they show such wide limits of variation as is displayed by the Jews in different countries. There are to-day more pronounced differences between the Jews in Prussian Poland and Russian Poland than between Prussian and Italian Jews, although but one hundred years ago the Prussian and Polish Jews were demographically on the same level. The part of Poland which was taken by Prussia with its liberal government has given the Jews an opportunity to assimilate with the christian population, while in the part of that country taken by Russia they were compelled to live isolated from the general population and they remained backward.

The demographic phenomena of the Jews are rooted in the social, economic and intellectual conditions in which they find themselves.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE. III.

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VI. *First Commercial Telephone Exchange*

THE first commercial telephone exchange system in the world was opened in New Haven, in January, 1878, and has been in continuous operation ever since. This pioneer exchange was organized by Mr. George W. Coy, who now resides in Milford, New Haven County, and who, during the twelve years ending with the year 1877, was managing the local offices of the Atlantic and Pacific and the Franklin Telegraph companies.

In July, 1877, the local papers in New Haven contained an advertisement of 'Bell's telephone' reading in part:

> The proprietors keep the instrument in repair, without charge, and the user has no expense except the maintenance of the line. It needs only a wire between the two stations, though ten or twenty miles apart, with a telephone at each end. . . . The outside of the telephone is of mahogany finely polished and an ornament to any room or office. Telephones leased and lines constructed.

In September, 1877, Mr. Coy secured several Bell telephones and installed a few private lines in New Haven, and also displaced some district call-boxes with telephones in his local messenger service. Perceiving how useful the telephone was proving to business houses desiring his messenger service, Mr. Coy concluded that a central telephone exchange system would be a desirable thing for the community, provided a sufficient number of subscribers could be secured.

Now in the beginning of the evolution of telephone exchanges, there was neither experience nor knowledge to guide the investor or the manager. There were no known methods of operation or of maintenance to render uniform and no equipment to standardize, because the to-be equipment had yet to be evolved from needs then unknown. The Bell company had no factory and supplied only the hand telephones, which were made to order under contract. Thus each licensee was largely thrown on his own resources and compelled to devise much of his exchange equipment and to secure from several different sources such associated apparatus as was available. Then the installation was necessarily made and the lines run with the aid of the telegraphers of that day. For in 1877–8, the only 'electricians' were the men associated with the telegraph companies. The electric light and the trolley then had no commercial existence. Thus, through the needs of the telephone exchange, was evolved that now very essential person the 'telephone engineer.' That is why Mr. Coy had not only to plan his own central exchange system, but also to devise the necessary switching mechanism for his central office.

Confiding his plan to his friend, Herrick P. Frost, the latter agreed to assist Mr. Coy. Not that Mr. Frost knew aught about the telephone or telegraph, but because he wanted to make a place for his son, then about sixteen. Neither Coy nor Frost could spare the funds necessary to build the exchange system, so Mr. Frost borrowed six hundred dollars from his brother-in-law, Walter Lewis, organized the New Haven District Telephone Company, secured a charter, and issued capital stock having a par value of five thousand dollars. Of this amount Coy and Frost subscribed for $2,000 each and $1,000 was transferred in November, 1877, to the parent Bell company for a license granting the exclusive right to use Bell telephones in the counties of New Haven and Middlesex, in Connecticut. Mr. Coy states that later this block of stock given to the Bell Company was repurchased by the treasurer of the company for two hundred dollars in cash.

By virtue of his services as the good angel so essential in pioneer undertakings, Walter Lewis was elected to the presidency of the company, Mr. Frost was made treasurer and Mr. Coy filled all the other offices. Morris F. Tyler was the company's attorney, secured its charter, obtained the necessary additional loans to enable extensions and improvements to be made, took his pay in stock, and later became the head of the organization. Incidentally it may be added that on May 31, 1878, Mr. Frost secured exclusive licenses to use telephones under Bell patents for the term of ten years, in the cities of New Haven, Hartford, Meriden, Middletown and New Britain, in Connecticut, and of Springfield in Massachusetts, subject to his leasing not less than five hundred telephones the first year, and expending not less than $8,000, including the amount already expended in New Haven.

Being ready to proceed with the installation of its 'telephone-call system,' Mr. Coy mailed to the prominent citizens of New Haven a thousand copies of a circular describing the many advantages the system would offer, and earnestly requesting subscriptions for the service. It was expected that at least fifty replies would be received, but only one subscription was obtained, and to the late Rev. John E. Todd, pastor of the Church of the Redeemer, belongs the honor of being the first person in the world to subscribe for the service of a commercial telephone exchange system. Quite rightfully Mr. Todd's name headed the first list of telephone subscribers ever issued.

So complete a failure to arouse public interest in the telephone system was a bitter disappointment to Mr. Coy. But being a born hustler, he immediately sent out a competent canvasser to solicit contracts. This agent succeeded in ultimately securing over two hundred contracts, for which he was paid a commission of one dollar each. The first contract thus secured was that of the New Haven Flour Company for five telephones, including one in each of its stores and one in the residence of its manager, Mr. George E. Thompson.

Mr. Coy commenced installing the telephones in November and it was his intention to have had his exchange in operation early in December, 1877, but so numerous were the mechanical difficulties that had to be overcome, so many electrical problems required solving, and so slow were the shipments of telephones, that it was not until January 28, 1878, that the exchange was formally opened, the first service being given on January 21, to about thirty subscribers.

Following the formal opening, the number of subscribers increased rapidly, and on February 21, 1878, appeared the first regular list of subscribers to a commercial telephone exchange. Fifty stations were listed. The second list appeared on March 9, 1878, less than three weeks after the first, and recorded about one hundred and twenty-five stations. On April 8, 1878, came the third list with two hundred and twenty-seven subscribers, including forty-two residences. Thenceforward there was a steady growth. In all these lists names only were shown. Numbering the subscribers to facilitate rapidity in securing connections was an afterthought. Even so late as April, 1880, and in so important a city as New York, the list of subscribers contained no telephone numbers, though there were about one thousand five hundred names distributed through six exchanges.

The rates established by Mr. Coy were only eighteen dollars a year for a telephone in either the office or the house. But it should be borne in mind that the circuits were of single iron wire and grounded, and that from ten to sixteen subscribers were on a line, a number that would not be tolerated in modern business service. Like many modern telephone men, Mr. Coy did not base his rates on what he thought the service was likely to cost him, for the eighteen-dollar rate was established before a pole had been erected, but on what he thought the public would pay. In January, 1877, the American District Telegraph Company introduced a rate of eighteen dollars a year for its call-box system in New Haven and cities of similar size, while it charged thirty dollars a year in the large cities. So Mr. Coy concluded he could supply a telephone as cheaply as a district-box could be furnished; and that is how the eighteen-dollar rate came to be established. Thus, as early as February, 1878, Mr. Coy was advertising in the local papers that 'the company rents them at the extremely low price of five cents per day, thereby placing telephones within the reach of all.' And on February 14 it was stated that Mr. Coy was 'supplying telephones in any part of the city, including service to Fair Haven and Westville (separate boroughs, one four miles, the other seven miles distant) for eighteen dollars per annum.' And it may be added that the gross receipts of the New Haven exchange in the month of February, 1878, were $250.

Mr. Coy was a great believer in press publicity and made liberal use of the advertising pages of the local papers, thus keeping the public informed concerning all extensions and repairs. In those days the weather reports issued by the United States Signal Service were very desirable. So Mr. Coy placed a telephone in the office of the weather observer, and on March 15, 1878, advertised that 'any one having a telephone can make inquiries as to the weather, temperature, barometer, etc.' A little later Mr. Coy built a pole line nearly seven miles in length and ran a circuit to the lighthouse at the east end of the harbor, thus benefiting shipping interests by the prompt transmission of cautionary weather reports, and also enabling his subscribers to keep track of the arrival of steamers and other marine craft.

On May 1, 1878, Mr. Coy had telephones 'placed near the targets,' and also 'at the shooting-stand,' connecting the latter to the central exchange, thus enabling his subscribers to keep informed concerning the scores made at the annual meeting of the rifle association. Another feature that is considered essentially modern was introduced in New Haven by this company. On November 4, 1878, it advertised that "in order to facilitate the collection of election returns from the different wards in this city, to-morrow, the company has made arrangements for placing a telephone in or near each voting place, in order that the returns may be sent to the central office as soon as declared. The returns will be furnished to any subscriber upon inquiry by telephone." Later the daily papers stated that 'the telephone was of great use in collecting and transmitting election returns.'

During the first two months Mr. Coy's exchange occupied one half of a ground-floor store room in the Boardman building, corner Chapel and State Streets, New Haven. This room then bore the number 219 Chapel Street, but is now 733. Then the exchange was moved to the top floor of the Ford building, directly across Chapel Street; but the office of the company remained in the Boardman building.

Until March 1, 1878, service was given only from 6 A.M. to 2 A.M., the night operator remaining on duty until that early morning hour in order that the newspapers might have telephone service up to the hour of going to press. For newspaper reporters quickly realized what a blessing the telephone was in accelerating the transmission of a scoop, or a good story, or a simple news item, and utilized the service on every possible occasion.

Prior to 1877, if anything happened at a point distant from a telegraph office, and branch telegraph offices in cities were few and far between in those days, reporters were in the habit of gathering the names of the participants and the essential facts, and then hastening with all possible speed to the editorial rooms. Late at night few horse cars were running (then the trolley-car was unknown), and rarely was it possible to secure cab or carriage on the scene of action; so getting a good story often meant a long, steady trot for many blocks before the editorial rooms were reached. To-day a reporter can prepare his copy on the premises, walk to the nearest telephone, talk it to an assistant in the editorial rooms who typewrites it as it comes over the wire, and the 'scoop' or 'story' is on the street in less time than the reporter of 1876 would have consumed in riding or running to his office. And with the aid of the telephone, the city editor in the large cities often makes many assignments without seeing the respective reporters for days at a time. In fact, in the larger cities, certain reporters now communicate by telephone with the editorial rooms every half hour while on duty, and only visit the main office to draw their salaries.

After March 1, continuous day and night service was given. During the first week one boy operator, Louis H. Frost, son of the treasurer, was the sole operating force; then Julian Cramer was added; on March 1 Fred A. Allen was employed; and later came Charles W. Dow. The night operator received a salary of $15 a month, and worked from 5 P.M. to 8 A.M. Incidentally it may be added that Mr. Allen and Mr. Dow are still employed in the New Haven telephone exchange, and that Mr. Frost is in the livery business in that city.

In building his subscriber-lines, Mr. Coy erected very few poles during the first four months. The grounded-iron circuits were supported on brackets fastened to the sides and roofs of buildings, and to trees, the owners of the property usually making no charge for this right of way. Owing to this method of suspension no two spans of wire were the same in length, and slack wire was in evidence the year through. Hence, it was only natural that the talking qualities of these circuits should never be very good, and invariably be very low whenever these wire festoons were swayed by the wind against tin roofs, or were grounded on wet roofs or on the dripping branches of trees.

Thus it naturally came about that on drizzling days the amount of shouting required on the part of subscribers striving to carry on a conversation with the aid of a single hand telephone was a source of much amusement to non-participants, and a probable cause of much profanity and ill-feeling to many users of the service. And all the blame was placed upon the little wooden telephone in place of the wretched construction and the circuits that were constantly being crossed or grounded on wet roofs or on the branches of trees. Had these early lines been built with all the care and under the engineering supervision now expended on the heavy copper metallic circuits, excellent talking service would, no doubt, have resulted. For there were few vagrant currents sneaking around in those days.

Yet back to these cheaply constructed subscriber-lines and that crude equipment is easily traced the origin of the marvelous system of intricate switchboard mechanism, practical and standardized methods, and progressive operation known as the modern telephone exchange, and by the aid of which a subscriber in New Haven may now talk with greater ease to a subscriber in Pittsburg, or in Chicago, than was possible when the two subscribers were distant only a block away on wet pioneer days in Connecticut. That is, less shouting would be required.

With the accumulation of experience in constructing telephone pole lines covering a period of a quarter of a century, we might wonder that Mr. Coy should have put up telephone lines of so crude a character. But from whom could he gain experience concerning the construction of telephone lines? He built the first commercial telephone line ever constructed. Owing to the bitter competition existing between the telegraph companies, the telegraphers of those days strove not to see how good a telegraph line could be built, but how cheaply it could be constructed and yet carry messages when 'sufficient battery' was used. Battery current cost but little, and properly-constructed pole lines brought no higher price than rickety lines, when the inevitable consolidation was brought about by cut rates. Then the promoter pocketed his profit, and the public footed the bill in an increase of rates to cover interest charges on the duplicate and non-earning investment. In the words of a governmental report dated January, 1869:

> There is no uniformity in telegraph rates. They are often less to a distant (competing) station than to an intermediate one on the same line. In other countries the rates are reduced with the growth of business and never raised. In this country they are reduced by competition, followed by consolidation of the competing companies, and subsequent increase of rates, without regard to the growth of the business.

Yet Mr. Coy followed the approved American practise of 1878, a practise that prevailed for several years thereafter, as is evident from the official instructions issued by the parent Bell company during the years 1879–81. And these instructions certainly make interesting reading, now that uniformity in methods and standardization in equipment and stability in construction are rigidly insisted upon by all legitimate telephone companies.

It was comparatively easy to run telephone circuits in those pioneer days when only telegraph or signal companies were stringing wires.

There were no trolley wires until 1884, and no central station lighting plants prior to 1879. In 1873 William Wallace was building his relatively large magneto-machines in Ansonia, which early in 1874 were connected up and used as dynamos in lighting his factory. In 1875 he brought out a more compact dynamo that 'was in operation furnishing current for electric lights in Machinery Hall during the entire period of the Centennial.' In 1877 two Brush 'dynamos built for lighting were exhibited and tested at the Franklin Institute in Philadelphia,' with a 'ring-clutch' arc lamp. The first Brush 'dynamo and lamp actually sold were shipped to Dr. Longworth, of Cincinnati, about January, 1878,' and installed by Charles F. Brush. In April, 1879, twelve Brush lamps were installed in Cleveland for street lighting, and 'on December 20, 1880, Broadway, New York, from Fourteenth to Twenty-sixth street was first lighted with fifteen Brush lamps.' The first Edison central station was opened in New York on September 4, 1882.

Ten years after the opening of the first telephone exchange central electric-lighting stations were in operation in all principal cities. Of electric railways, in the beginning of 1887, in the United States 'there were only ten installations with an aggregate of less than forty miles of track and fifty motor cars, operated mostly from overhead lines with traveling trolleys.' The principal practical pioneers were Charles J. Van Depoele who built an experimental trolley system in Chicago in 1882–83; Leo Daft who, a year later, operated an experimental electric locomotive at Saratoga; Bentley & Knight who placed an experimental conduit system in operation in Cleveland, in August, 1884; J. C. Henry who completed the trolley system in Kansas City in 1884–85, and Frank J. Sprague's experiments in 1885.

FOSSIL INSECTS AND THE DEVELOPMENT OF THE CLASS INSECTA[1]

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TO the majority of mankind, who supposedly are inclined to look on the bright side of life, the sound of the word 'insects' ever recalls the picture of a wide-awake boy with a green net and possibly with a botanical box of the same hue, but more vivid in color, chasing along after the variegated butterflies and beetles. He seldom overtakes them, but positively assures us that he already has a 'nearly complete collection of insects of fifty or more species.' With this same word 'insects' many a pessimist, however, will bring to mind only the small troublesome pests of his home, perhaps even of his own worthy person, or certain minute organisms to which he indirectly ascribes the cause of the more and more frequently recurring adulteration of his wine. In each instance, the matter will be quickly despatched either with a good-natured smile or with a gentle imprecation, and only rarely does *Homo sapiens* attempt to make clear to himself what the word 'insects' really signifies.

That insects constitute a subdivision of the Arthropoda, to which group spiders, crabs and myriapods also belong, and that they are distinguished by the possession of only six legs and four or two wings, have with other details doubtless been acquired at school, where, too, knowledge was surely gained of many forms because of their usefulness (bees and silkworms) or because of their injurious character (moths, bark-scarabs and plant-lice).

Of the immense part that insects play in the household of nature and especially in science, however, of their truly wonderful diversity in bodily structure, of their organization, habits of living and development, as well as of the number of species, the greatest ignorance still prevails everywhere.

In proof of this not too flattering assertion, therefore, we will at once proceed to give a statistical summary, strictly in round numbers, of the insects now existing and scientifically recorded and named.

About 3,000 species of grasshoppers and crickets (Locustidæ and Gryllidæ) are known, whose music fills the woods and meadows of both

[1] Translated from the German by Lucy Peck Bush, Peabody Museum, Yale University. (Mitt. d. Sect. f. Naturk. d. Osterreich. Tour.-Klub, April, 1905, pp. 25–30.)

hemispheres; and about 4,000 species of their nearest relatives, the locusts, or Acrididæ, to which group the notorious migratory locusts also belong. It is estimated that there are about 2,500 kinds of specters, or walking-sticks (Phasmidæ), which inhabit tropical regions chiefly and are noted for their close resemblance to twigs and leaves. Much smaller is the number of those creatures called earwigs, although they are neither worms nor crawl into the ears; scientifically they are termed Dermaptera, and comprise about 500 species. Less noteworthy are the 200 forms of small thrips, or Physopoda. The stately, but harmless, praying-crickets, or Mantidæ, are represented throughout the world by only 800 different species. On the other hand, about 1,200 kinds of cockroaches, or Blattidæ, are known, and this family unfortunately includes the small Croton-bug and its larger black cousins. In warm countries, with these troublesome creatures are associated about 400 different species of white ants. The very small insects called body-lice, book-lice or wood-lice, which belong to the Corrodentia or Copeognatha, are represented in almost equal numbers. Mallophaga (bird-lice, which should not be confounded with bird-ticks) already number 1,300 species, for nearly every kind of bird has its special parasite. On the other hand, luckily, only 50 species of true blood-sucking lice have become known, a relatively high percentage of which afflicts mankind. One hundred and sixty thousand species is certainly not too large a figure to include the hosts of beetles, or Coleoptera, which people every corner of the globe, and may be obtained in the region of perpetual ice as well as in salt marshes. We are acquainted with but 52,000 species of Hymenoptera, or membrane-winged insects, among which are the many 'wild' relatives of the honeybee, the colonies of ants, the true wasps, digger-wasps, ichneumon-flies, gall-flies, saw-flies, golden-wasps and wood-wasps. Of dragon-flies, or libellids (Odonata), there may be about 2,300 different kinds at present described, while 300 species of May-flies (Plecoptera) and stone-flies (Perlidæ) are recognized. True Neuroptera (netted-winged insects), which also include the ant-lions and lace-winged flies, number 1,400 species; Panorpidæ, or scorpion-flies, about 100, and caddice-flies, or Phryganeidæ, 1,200. After the beetles, the forms most abundant in species are the butterflies, or Lepidoptera; of these science has disclosed the existence of about 55,000 species up to the present time. Next come the much less noted two-winged insects, or Diptera, of which two main groups, Orthorrhapha (midges, gnats, horse-flies, etc.) and Cyclorrhapha (true flies), with 14,000 and 30,000 species, respectively, share in the sum total of insect forces. The number of fleas, or Suctoria, is small in comparison, only 100 species as yet being known, one of which lives on the blood of mankind. Further, if the 30,000 kinds of bugs, cicadas and plant-lice included in the Hemiptera, or half wings, are counted, the round sum of 360,000 species of insects now known is reached.

Estimates have been given showing that not more than one sixth of all forms actually existing have as yet been described and named, so that the number of species (not individuals) now living in the present period of the earth's history may be placed at about 2,000,000.

It is quite conceivable that man in his effort to understand nature everywhere surrounding him should not be satisfied merely to study all these existing insects and arrange them in a system of orders, families, genera, etc., but he would also wish to know how this greatest division of the animal kingdom, in specific numbers about doubly exceeding all other groups, has been developed, and how and when it has attained its present size.

If we would really learn the primitive history of the insect tribe, and not construct it in a speculative manner, we must descend into the depths of the earth in order to see whether or not a fortunate chance has possibly preserved some remains which might afford us an insight into the insect life of previous ages.

If, as mentioned above, the number of various species of insects now existing be taken in round numbers at 2,000,000, and for each species at least 1,000,000,000 individuals yearly, which, judging from the swarms of bees and gnats, colonies of ants and termites, parasites of plants (often millions living on a single tree), certainly seems legitimate, an annual total of 2,000,000,000,000,000 (two thousand trillions) individuals is obtained, while during the time that man has inhabited the earth some hundreds of trillions must have existed.

And of all these trillions of insect remains, which moderately computed (about 100 to a gram) represent 1,000 billion kilograms in weight, we have as yet found but a few hundred examples, and these have been accidentally enclosed in gum (copal), in peat-beds, or finally buried in hardened mud. They have thus become more or less well preserved, and again by chance have fallen into our hands. All these forms clearly demonstrate that the species of insects have not materially altered during man's sojourn on the earth.

It may now be concluded that these results must lead only to discouragement, for they show very plainly how small a percentage of the insect world escapes complete destruction, and how slight is the prospect of securing any of these remains.

Notwithstanding this, it has already come to pass that quite a number of fossil insects have been brought to light from analogous deposits of older periods, and the explanation may be partly found in the fact that even these older strata are to be estimated not only by thousands, but probably by millions of years, so that the sum total of vanished and preserved forms must evidently increase accordingly.

Although in comparison with the hosts of living forms, researches hitherto made have resulted in the insignificantly small number of about 10,000 species of fossil insects, yet these few afford us a glimpse into the insect life of past ages. Such a collection of extinct species, moreover, much exceeds in numbers the recent forms in most university and private collections, which have become the basis of so many bold hypotheses. We can thus see or at least have some idea how in the course of millions of years the present mighty tree has grown up from so small and tender a plant.

Of the fossil insects thus far obtained, the larger part have come from that important period immediately preceding the age of man. This is designated the Tertiary period, or the age of mammals. Those insect remains preserved in fossil gum (Baltic amber), like artistic and permanent microscopic preparations, are indeed well known, and of these many thousand specimens have been accumulated in museums. On the other hand, less noted, but not less numerous, are the wonderful impressions found in many places in laminated shales, as in Œningen (Baden), Radoboj (Croatia), in Italy, on the Rhine, in Provence, in North America, etc. These are to be likened to nature's own printing and provide us with an atlas of the Tertiary fauna in which we find very many species that can scarcely be distinguished from those living to-day. With the exception of bird-lice, lice and fleas, all the principal existing groups of insect throngs are represented in Tertiary time, but the remarkable bizarre forms which especially delight our eyes to-day were much fewer in number then than now. Thus very few large butterflies and no striking types of beetles, such as we are accustomed to see in all shop-windows of the dealers, have been discovered.

Even though the character of the Tertiary fauna in general did not vary essentially from that now in existence, still the distribution of forms over the earth must have been far different. For instance, in Germany we find elements that now are met with only in tropical lands, from which follows many a conclusion as to the variations of climate and of the plant world. Moreover, the numerical distribution of species in kindred groups was likewise not the same as that at present in force, since among the Tertiary Hymenoptera a much smaller percentage of bees is found, among the Diptera there are more gnats than flies, among the Orthoptera far more grasshoppers than locusts, and only very few walking-sticks, etc.

Further, when it is stated that in the Tertiary period no single type of insect has been hitherto identified which does not still exist, and that therefore the numerous amber preparations and the impressions so beautifully preserved are as yet capable of giving no direct answer to our question, we must then turn to the next older period,

Tabular Summary of the Development of Insects in the Various Geological Periods

	Number of Known Species Actually Existing.	Tertiary.	Cretaceous.	Jura.	Lias.	Trias.	Permian.	Uppermost Upper Carbon.	Middle Upper Carbon.	Lower Upper Carbon.
Palæodictyoptera (primitive insects, ancestors of all other groups)	0	0	0	0	0	0	0	+	+	+
Protorthoptera (ancestors of the orthopteroids)	0	0	0	0	0	0	+	+	+	0
Orthopteroidea:						?				
Orthoptera (straight wings):										
Locustoidea (grasshoppers and crickets)	3,000	+	?	+	+	?	0	0	0	0
Acridioidea (locusts)	4,000	—	?—	0	0	0	0	0	0	0
Phasmoidea (specters, or walking-sticks)	2,500	—	?—	—	0	0	0	0	0	0
Dermaptera (earwigs)	500	—	?—	0	0	0	0	0	0	0
Physopoda (thrips)	200	—	?—	0	0	0	0	0	0	0
Protoblattoidea (ancestors of the cockroaches and mantids)	0	0	0	0	0	0	+	+	+	0
Blattüformia:										
Mantoidea (praying mantes)	800	=	?	=	=	?	—	0	0	0
Blattoidea (cockroaches)	1,200	=	=	=	=	?	+	+	—	0
Isoptera (termites)	400	=	?	0	0	0	0	0	0	0
Corrodentia (wood-lice or body-lice)	400	=	?	0	0	0	0	0	0	0
Mallophaga (bird-lice)	1,300	0	0	0	0	0	0	0	0	0
Siphunculata (true lice)	50	0	0	0	0	0	0	0	0	0
Coleopteroidea:										
Coleoptera (beetles)	160,000	=	=	—	—	—	0	0	0	0
Strepsiptera (fan wings)	10	=	0	0	0	0	0	0	0	0
Hymenoptera (membrane wings)	52,000	=	—	—	0	0	0	0	0	0
Mixotermitoidea (extinct provisional group)	0	0	0	0	0	0	0	0	+	0
Hapalopteroidea	0	0	0	0	0	0	0	+	0	0
Hadentomoidea (? ancestors of the embids)	0	0	0	0	0	0	0	0	+	0
Embioidea (embids)	50	+	?	?	?	?	?	0	0	0
Perloidea (stone flies)	300	+	?	+	?	?	+	0	0	0
Protodonata (ancestors of the odonatids)	0	0	0	0	0	0	+	+	—	0
Odonata (libellids)	2,300	=	?	+	+	?	0	0	0	0
Protephemeroidea (ancestors of the plectopteres)	0	0	0	0	0	0	0	+	0	0
Plectoptera (ephemerids, or May-flies)	300	=	?	+	?	?	+	0	0	0
Neuropteroidea (netted wings)	1,400	=	?	+	+	—	0	0	0	0
Megasecoptera (ancestors of the panorpoid series?)	0	0	0	0	0	0	?	+	—	0
Panorpoidea:						?	?			
Panorpata (scorpion-flies)	100	=	?	+	+	?	?	0	0	0
Phryganoidea (Trichoptera, or caddice-flies, etc.)	1,200	=	=	=	=	0	0	0	0	0
Lepidoptera (butterflies)	55,000	—	—	—	0	0	0	0	0	0
Diptera (two wings):										
Orthorrhapha (midges, gnats, horse-flies, etc.)	14,000	+	?	—	—	0	0	0	0	0
Cyclorrhapha (flies)	30,000	—	?	0	0	0	0	0	0	0
Suctoria (fleas)	100	0	0	0	0	0	0	0	0	0
Protohemiptera (ancestors of the half wings)	0	0	0	0	0	0	+	0	0	0
Hemiptera (half wings)	30,000	=	=	=	—	?	—	0	0	0

The signs +, —, = denote that, compared with the same group as now existing, a group falling in a given period was relatively more abundant, smaller, or equally developed, respectively, in the next younger period.

the Mesozoic, or the age of reptiles. Of its three chief divisions, Cretaceous, Jurassic and Triassic, the first mentioned and youngest has thus far yielded only a small number of fossil insects. During the Cretaceous, the flowering plants came into existence, and on this account it may be concluded that a multitude of new conditions were furnished for many kinds of insect forms. The bees and various other honey-eaters could thus have originated. The fact that insects immediately adapted themselves to these new plants is to be seen in the few specimens thus far obtained; that is, in the galls and eaten places on the leaves of the oak, willow and Eucalyptus, etc. Other than these, unfortunately, but little evidence of insects has been found in the Cretaceous.

On the contrary, the remains of this group preserved in Jurassic deposits are very large in number. These have been discovered in England, Spain and Russia, but nowhere in such quantities and remarkable preservation as in the Jura of Franconia in northern Bavaria, where in previous epochs a shallow sea between coral reefs became filled up with the finest calcareous silt. Many of the insects which peopled the neighboring land found their graves in this mud. By a fortunate chance, after perhaps millions of years, these forms have now come to us, for this same hardened mud is to-day used by us as lithographic stone or paving-stone.

Now what does this rich collection of Jurassic insects teach us? It shows that in that period probably an entire series of groups of living forms either then had no existence or were just in the process of evolution. As yet are found no locusts, no earwigs, termites, thrips and wood-lice. Of the Diptera, the only representatives are those which are in the minority to-day; of the Hymenoptera, the wood-wasp, saw-fly and ichneumon-fly alone appear to have been present, while bees, ants, etc., are wanting. Some primitive forms of butterflies have been discovered, but these were at first erroneously regarded as cicadas. Grasshoppers were abundantly developed and some of them, judging from the structure of their legs, may have run about on the water or wet mud quite as water-striders, a genus of aquatic insects, do at the present time. Through their changed habits of living, these water locusts thus appear to have modified the legs no longer needed for jumping, and in this way the specters, or walking-sticks, may have finally originated. Dragon-flies, May-flies, Neuroptera and Hemiptera were represented in great variety, and of the last group there were aquatic species as well as those terrestrial; also small cicadas. Beetles, too, were not wanting, although no particularly striking forms are to be distinguished.

The fact that Jurassic insects were so extremely abundant clearly indicates a warm climate, and the school children of Bavaria would have to provide themselves with much larger nets should the thousands of past generations of insects celebrate a joyous resurrection, for the size of these Jurassic representatives was from four to five times that of many forms now existing in the Danube region.

But these fertile years were apparently preceded by others more barren. At least this impression is gained when we contemplate the swarms of insects that lie buried in a stage still lower—the Lias, or black Jura. The discovery of some rich localities in Switzerland, in Mecklenburg and in England, for instance, have yielded almost absolutely dwarf species. On the average, these forms were even smaller than those inhabiting the same regions to-day; truly starved species. In fact, at that time there were as yet no butterflies, few Hymenoptera, and no other striking insects. The beetles and gnats found were small and insignificant. On the other hand, caddice-flies and scorpion-flies were abundantly represented, the latter of which now play only a limited part. There were also dragon-flies of moderate dimensions, bugs and small cicadas similar to our frog-hoppers; grasshoppers and locusts, and the ever-present cockroach as well.

From the long Triassic period that stored up a large part of the material from which the imposing dolomite towers were subsequently formed, we as yet unfortunately know only some insignificant beetles and Neuroptera. Hence, we can turn at once to that very ancient period called the Paleozoic. On important but purely material grounds, this epoch stands very close to mankind in general, since it includes the most valuable coal deposits, the mining of which has materially aided our present studies. In and near the coal in many places in Europe and North America has been found a great number of impressions of insects whose investigation furnishes us with an entirely new world of forms.

Although in the upper beds of this period no more beetles and Neuroptera are found, yet caddice-flies and scorpion-flies, gnats and locusts, too, are wanting. So much the more do the cockroaches increase! May-flies and stone-flies were already represented, and Hemiptera as well, but of a form that it is not known whether they should be pronounced cicadas or bugs.

In addition we also find insects that it may not be possible to arrange in the established classification of living forms, although affinities with the latter are undoubtedly to be recognized. The deeper we descend into the coal period, these forms more and more increase in number, while modern types gradually become less and less frequent. It may therefore be concluded that in the Carboniferous forms the direct ancestors of many of the insect groups previously mentioned are to be sought, and hence corresponding names have been chosen for them: as Protodonata, the ancestors of the Odonata, or libellids;

Protorthoptera, ancestors of the Orthoptera, or locusts, etc. Nearly all these insects attained a considerable size; indeed, there were many the span of whose wings measured much more than half a meter—they were literally giants!

These forms, too, decrease in number, and at last there appears to us a quite distinct fauna of primitive creatures, whose structure was of the simplest order, and who were apparently without adaptation to the definite modes of life which we are accustomed to see in nearly all existing insects. These primitive forms we call 'Palæodictyoptera,' and among them it is possible to distinguish a series of different genera and species, all, however, having common characters and standing in about the same degree of relationship to existing groups.

These palæodictyopteres, therefore, constitute the first shoot of the giant tree which we have to-day in the insect world.

As has been frequently indicated, we also see that the race of insects has by no means remained unaltered since primitive times, but that it has been subjected to precisely the same changes as have other groups of animals. And the conclusions to be drawn from these mutations are manifold. In the first place, they permit us to erect a natural system in accordance with actual descent; they permit us to weigh the characters accurately and to distinguish between those which are old and inherited and those that are recent and acquired. Moreover, they afford us many and far-reaching conclusions regarding the climate and the nature of the soil in those times and regions, as well as the distribution of land and water, etc. Finally, by this means we are also enabled to penetrate a very little into the future. And this further shows us that eventually neither the boy with the green net nor the imprecating pessimist will be so very far wrong, for the immediate future probably belongs to the brilliantly colored insects, on the one hand, and, on the other, to the troublesome and offensive vermin, the parasites of man, animals and plants. These two extremes appear to us to-day in their greatest development.

NATURE NAMES IN AMERICA

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WHEN Adam, or the cave man, began giving names to the things of the earth and the things of the sky, it was probably with a view to a better personal acquaintance with the objects and for a ready means of conjuring up their images to the mind. In the same spirit a learned professor later defined a system of classification as a series of pegs to hang ideas on. If we are of a mind with Juliet as to the matter of calling a rose by any other name, we accept an undeniable fact, a scientific proposition, but we are at the same time in danger of losing a certain flavor and zest of life, a subtle something in our conscious relation to the things of this world. At least this is true of those of us who are highly endowed with a sense of the fitness of a name for the thing that it stands for. It is more than likely that the man or woman possessing this keen relish for a name will unhesitatingly repudiate the statement of Juliet, preferring rather to live in the delightful delusion of the name itself. It is the conjuring up the image of the thing, the making it a part of the inner conscious self, that has so much to do with the background of our happiness. How could it be otherwise in this age-long association of words and things? Our life is a life of words, and whether we see the printed word, or hear it spoken, it is to us one with the thing itself, and the thing itself is but the word materialized.

This delight in a word for the sake of its associations, though intensely personal, is after all in a large way a matter of race history. What we call the 'mother tongue,' an expression that in itself suggests the most vital relation in human life, is the handing down of inherited speech; as important in its way as the transmission of blood and of brain cell. As the bodily substance may change under the influence of new environments, so a language may change under like conditions, and yet each will bear throughout its structure the large features of its ancestry. It is a matter of some interest to trace out the effects of the new world on the thought and speech of the early colonists and the incorporation of any changes thus wrought into the language of the people. In pursuing this inquiry I have directed my attention to the names imposed by the settlers on the natural features of the land and the more familiar living objects, such as plants, mammals and birds. These were obvious features in the physical environment, a knowledge of which was often of the first moment to the pioneer, and their names stand for a certain attitude of thought toward things more or less familiar or things entirely new and strange.

The English stock that colonized the greater part of the Atlantic seaboard of North America, very early left the marks of its language on hill, valley and stream, and on fauna and flora. What objects it did not designate with old world names were called by the names known to the aboriginal peoples—Indian names—usually much altered phonetically. In some instances names were invented directly as expressive of some notable characteristic, and, again, some few were borrowed from the languages of alien settlers. A very large proportion of the names of natural objects in America are transplanted old world names, a fact not at all surprising when we consider the general similarity in topographical features and in the life forms, both plant and animal, of eastern North America and western Europe, notably England. A comparison of the forest trees of North America with those of western Europe shows that a large proportion of the various kinds are common to both sides of the Atlantic. The settlers found much the same aspect of woodland that they had known at home. There were oaks and beeches little different from those of Europe. The same was true of the pines, firs, spruces and larches, and of the birches, alders, aspens and poplars. The maple, elm, ash, plane tree, chestnut, walnut, cherry, hazel and dogwood were broadly recognized as familiar trees, though differing somewhat from their transatlantic representatives. The comparatively few trees that were entirely strange to the early colonists, as the hickory, sassafras, persimmon, magnolia, buckeye and tulip tree, came to be known, for the most part, by their aboriginal names, though much corrupted both in spelling and in speech. The two last named trees—the buckeye and the tulip —were so called, the first from the fancied resemblance of its nut to the eye of a deer (a true backwoodsman's comparison), and the tulip tree from its gorgeous blossoms. Beverley in his 'History of Virginia' (1705) speaks of 'the large Tulip Tree, which we call a Poplar.' The tree is not a poplar, but belongs with the magnolias, and the compound 'tulip poplar,' frequently used at the present time, is an unfortunate misnomer. The general similarity of the forests of eastern North America and western Europe is the result of certain geological conditions, among which was a once more or less continuous land connection between the northern portions of the two continents, together with a climate that allowed of a very wide dispersal of plants and animals. Among mammals, the bear, wolf, fox, deer, hare or rabbit, weasel, otter, badger, beaver, squirrel and others were recognized as being closely allied to similar old world types. But with the curious racoon and opossum, the colonists knew of no European animals in any way like them, and we find John Clayton, in 1693, naïvely writing of the racoon as 'a Species of a *Monkey*.' Besides racoon and opossum the Algonquin tongue has given us such words as 'skunk,' 'chipmunk' and 'moose.'

The early colonists, Puritan and Cavalier alike, were in the main English yeomen. They came not from the crowded centers, but from the rural districts, and it matters little from what district they came, all had been in touch with nature in England, and planted deep in their hearts was the love of fields and woods. This was not often expressed, it was too deep-seated a sentiment, but we see its workings in many an old chronicle. It was not what in the modern sense might be termed poetic, though there were undoubted poets among them. It was rather the feeling that an unlettered countryman has—a certain inexpressible love for the soil and the things thereof. The English emigrant to America was too much a part of his surroundings to see nature from the poet's point of view. The modern esthetic cult—the love of the beautiful—was not a portion of his mental equipment. He had the inquisitive and acquisitive qualities of mind, the interest in things for the sake of knowing about them, the attitude of the curious, and, above all, an interest in the practical uses of natural products. With this attitude of mind toward nature he set foot upon the shores of the new world. The surroundings that he had left are best pictured in the rural England of Shakespeare's and of Milton's time. The richly green meadow pastures watered by abundant streams, along the banks of which Walton and his brother anglers loved to loiter in the shade of broad-spreading trees; the rolling uplands and lines of low hills; the deeply ploughed fields and scattered masses of woodland, with here and there a church spire peeping above them; the hedge-rows blossoming with wild flowers and haunted by innumerable song birds; ancient, ivy-mantled towers and drowsy hamlets, with noisy flocks of rooks and daws—these were the elements in a landscape enveloped in the soft atmosphere of an English sky, and with all the endeared associations of home, that the emigrant carried in his mind and heart to America. Little wonder that he sought in his new surroundings for something to remind him of this old home. The forbidding, untrodden wilderness hemmed him in on every side. The puritan found a rugged land and a harsh climate; the cavalier, a more generous display of nature; but each had to wrest wide areas from the wilderness before the landscape could become in any sense domestic. As this domestication of the land went on, the colonists found birds coming about their dwellings, building nests in their gardens and in the shelter of their barns, and they began taking note of many of the wild plants that grew in their neighborhood. By the time some of the earlier accounts were written, the settlers had already made the acquaintance of a number of the more familiar kinds and had given them names. It was the England of Elizabeth that was transplanted in New England and Virginia, and a considerable body of old world folk-lore was a part of this transplanting much of which has come down to us in the names of plants and in the various other forms of speech. Garden-craft and the 'art of simpling' was a part of every housewife's knowledge, and plants were diligently sought for their healing virtues. Knowledge of this kind was also to some extent gained from the Indian inhabitants. In all the earlier descriptions of the new world such objects had a prominent place, together with the character of the land and aboriginal peoples and the advantages for settlement. One can see in these accounts the evident striving of the European mind to find suitable names and to describe an object by its likeness to familiar objects at home.

The few records that we have of the impressions of the earlier colonists are scattered through old journals, letters and histories of travel, and the references to plants and animals are often exceedingly obscure as to the species indicated. The question of the origin of names is at best recondite. Names are part of the folk-lore of peoples; they came into existence far back in a dim past, long before the period of written history. When we do find them gathered in ancient vocabularies, as in the one of Aelfric (955–1020 A.D.), we may be sure that they were even then venerable with age. The new world has added comparatively little to the stock of old world nomenclature. More often an old name has been given to an entirely different thing from the one that it originally stood for, and has been twisted into a new meaning with new associations. Thus the word *creek* originally meant the tidal estuary of a small river, a place where vessels might find harbor, and it is so used throughout Great Britain to-day. In certain parts of the United States, notably along the middle and southern Atlantic seaboard, the word has been extended to the small tributary of a river throughout its entire course. In England these little inland streams are called 'brooks,' which is clearly their rightful name—shallow water-courses with much tumbling and bickering over stony places. Milton very clearly distinguishes between the two where in 'Paradise Regained'

> Freshet or purling *brook*,

may be contrasted with the lines in 'Paradise Lost'

> Forthwith the sounds and seas, each *creek* and bay,

Both are here pictured with their characteristic associations, the one as an upland stream, the other as a tidal inlet. In the Bible the word 'creek' is used with perfect clearness as to its meaning in the description of Paul's shipwreck—"And when it was day, they knew not the land: but they discovered a certain *creek* with a shore, into which they were minded, if it were possible, to thrust in the ship." Here we have the idea of a harbor in the use of the word. It is possible, I think, to see how our brooks have come to be called 'creeks' when we reflect that south of New England the large rivers have many smaller streams emptying into their tidal waters. The mouths of these are often deep enough to make a shelter for vessels, and they were undoubtedly so used by the early settlers. Hence the term 'creek' and its extension to the entire stream and to other similar streams far inland throughout a wide extent of country.

In portions of the middle Atlantic region the word 'cripple' was formerly used for dense, low-lying thickets, especially in wet ground. As a boy I occasionally heard it applied in this way, and it is quoted by Murray as occurring in the Penn-Logan Correspondence (1705). None of the dictionaries, however, attempt to trace it back to any dialectic source, nor is it given, with like meaning, in the vocabularies of provincial English. In the dialect of east England 'creeple' means to compress or squeeze, which might suggest the notion of a thicket. But words were not coined by the early settlers through mere suggestion; they had an ample supply for every-day use. This word 'cripple,' from its very local character, is undoubtedly a corruption of the Dutch word 'kreupelbosch,' signifying 'underwood,' the Anglicized form having been shortened by dropping the terminal 'bosch,' which means a wood or forest, and is allied to our now obsolete words, bosky and boscage. 'Kreupel' is an adjective meaning lame and suggests a creeping or halting mode of progression as in the common use of the English word. One who toils painfully through thickets with much inward, if not with outward, cursings will appreciate this most expressive word borrowed by our English settlers from their Dutch neighbors on the Hudson.

Swamp is more generally used in the United States than in England. It does not occur in the writings of either Shakespeare or Milton, though some of the minor poets make use of it and it is frequently found in the early descriptions of the colonies. The word implies wet, boggy ground in woods, with rank undergrowth, and is eminently characteristic of the wilder conditions of this country as compared with the more highly cultivated lands of Europe. The settlers, in this instance, had a keen sense of the fitness of the name. They early distinguished the treeless stretches of salt grass along the seacoast and river estuaries by the word *marsh*. *Fen* rarely if ever finds its way into American speech and writings, except when used in a poetical sense, as in Longfellow's 'fens of the Dismal Swamp.' *Swale* appears to have two meanings, a shady spot and a low rise of land. In provincial dialects it means both a vale and a shady place and in Northamptonshire 'a gentle rising in the ground.' In the western United States it refers to a boggy depression in a generally level stretch of country, and as a local word in New England it signifies an interval (intervale) or hollow, an umbrageous spot—the haunt of woodcock and other wild folk. *Valley* has replaced the older 'vale,' which now is found only in the poets' verse, and 'dale' has likewise suffered a decadence save in the northern counties of England. Both vale and dale, however, survive as the terminations of many place-names in England and the United States. Valley seems to be equivalent to the lowland along a river's course, while vale and dale have to do with smaller streams, or more often with woodland hollows. In the following passage there is evidently this view in the writer's mind:

> **The Land higher up the Rivers throughout the whole country, is generally a level Ground, with shallow Vallies, full of Streams and pleasant Springs of clear water, having interspers'd here and there among the large Levels, some small Hills, and extensive Vales. (Beverley's 'Virginia.')**

In the south, and to some extent in the western states, the word 'branch' is widely used for brook. Beverley, in his account of Virginia, speaks of 'Gravelly Branches of Chrystal Streams.' *Freshet,* now synonymous with the overflow or flooding of a stream, was formerly used in the same sense as brook, as in the line of Milton above quoted. The term is said to be locally in use in Maryland to-day. Once when fishing along a small stream in southern Nova Scotia, a young lad who accompanied me remarked that it was 'most too low a freshet for good fishing.' This was a new meaning of the word to one who always had associated it with floods, but it was without doubt a survival, in a slightly altered form, of its original sense. The Anglo-Saxon *Fersc,* from which the modern English 'fresh' is derived, meant 'on the move,' and was originally applied to 'running' or 'fresh' water. *Run,* synonymous with brook, is a survival in America of 'rine,' 'rindel' and 'runnel,' of old English dialects.

The word 'rabbit' perpetuates a surprising want of observation on the part of those who first gave this name to the American species. The so-called 'rabbits' of this country are hares, not rabbits. Yet one would argue himself unknown who was pedantic enough to speak of hare-shooting before the 'great unwashed democracy of America.' The true rabbit is an old world species, makes burrows for its habitations, and brings forth helpless, naked young, as every boy knows who has kept tame rabbits. The wild 'cotton-tail' of this country, and all its kin, never burrow, but make a 'form' like the true hares of Europe, and the young are lively, well furred little creatures from the moment of birth.

America has lost some pleasing words which the English heart still holds dear through many delightful associations. *Copse* and *coppice* are thus lost to us on this side of the Atlantic. I feel sure that many who live their lives in literature would be glad to call some beloved patch of underwoods a 'coppice,' just for the sake of literary associations. One can do so to himself if he likes, but it is best to say 'thicket' to the world at large. And thicket is an old word and a good one too, even when shortened to 'thick,' as in provincial English. It savors of wilder places than coppice, which refers to underwoods that are annually cut for fuel and which put out fresh shoots each year, while thicket has about it more of the delightful abandon of nature. We are not alone in this matter of lost words in the common speech. In England, as well as in America, the word *glade* has passed from every-day speech, and more 's the pity, for it is a charming word when associated with its real meaning of an open, sun-lit space in the woods, a place of gladness in the midst of gloom.

The varied features of the American wilderness—swamp and creek, hill, dale and river valley, and over all the forest of a primeval world with its wild life untouched by any hand save that of nature—these waited the coming of a people that would give them, by name and word, a place and part in another world, a world of literature. A large measure of man's curiosity concerning the things of his environment has been directed to finding out the nature and virtues of the divers kinds of plants that seemed to grow mainly for his use and delectation. This plant lore antedates the oldest written history. From the very beginning it has been a part of man's self in the food question and in the healing of bodily ills. The greater number of our wild herbs and trees, as well as the long domesticated varieties, received their names in a time so long past that only the names themselves can reveal their origin. Here is history that outdoes Homer and Herodotus and all the writings of the ancients. In the words of Prior, the author of British Plant Names, we are led, in thinking over these names, "to recall the times from which they date, to picture to ourselves the living figures of our ancestors, to hear them speaking their obsolete dialect, and almost to make the weeds that shadow their grave tell more than their tombstone of its sleeping inhabitants."

The early colonists found many plants in the new world of kinds with which they were more or less familiar. Hence we find a predominance of European names in our American flora. Aside from this, many old world species began shortly to make their appearance in America and soon became naturalized on American soil. It is a matter of some interest to run through a Gray's 'Manual' and note how many of the species are naturalized from Europe. The origins of a large number of our English plant names are involved in a curious attitude of the medieval mind toward the productions of nature. These were regarded as presenting by their forms, colors, or other properties, tokens of the Divine will for the benefit of sinful man. This remarkable idea was embodied in what was known as the doctrine of signatures, and is thus set forth by William Coles in a quaint old work entitled the 'Art of Simpling.'

> Through Sin and Sathan have plunged Mankinde into an Ocean of Infirmities, yet the Mercy of God which is over all his workes, maketh Grasse to grow upon the Mountains, and Herbes for the use of Men, and hath not only stamped upon them a distinct forme, but also given them particular Signatures, whereby a Man may read, even in legible characters, the use of them.

A name that is dear to us as a welcome of the spring—hepatica—

came through this curious belief in signatures. Its three-lobed leaves were supposed to bear some resemblance to the lobes of the liver; hence, according to the doctrine of signatures, the plant must possess virtues that would heal the manifold complaints of that organ. Whitlow grass, the *Draba verna* of the botanist, was thought to be good for the whitlow or felon. Bloodroot, because of its red juice, could cure the bloody flux. Dandelion, *dent de leon,* was so called, according to Prior, by one Meyster Wilhelmus, a surgeon, as set forth in the Ortus Sanitatis of 1486, from its wonderful virtue in the curing of disease, likening it to a lion's tooth. Saxifrage, comfrey, birthwort, eyebright, self-heal or heal-all, St. John's-wort, sanicle and a host of other more or less familiar wild flowers, each bore some token of its use in the healing of various diseases.[1]

There were many plants, however, that were named for other reasons than that of signature, plants that were not reckoned in the art of simpling. The daisy was the 'eye of day'—dæges-eage—of the old Anglo-Saxons, but the daisy that we know in America—the pest of the farmer and the delight of the wayfarer—is not the daisy of Chaucer and of Shakespeare. It is the great or ox-eye daisy, a plant of a different genus. Why the 'wee, modest, crimson-tipped flow'r' of Britain's fields never gained a foot-hold in this country, while the great, white ox-eye has become naturalized as our American daisy, is one of those questions which the student of distribution has to solve. If we can not have the poet's flower itself we must at least have the name; that is the privilege of our inheritance. It matters little if we give the name to another, even though it be a 'pernicious weed'; the name, aside from the intrinsic beauty of the flower, endows it with a charm that can never fade. Our eastern buttercups are mainly naturalized species. The one that is truly indigenous—the early crowfoot (*Ranunculus fascicularis*)—grows on rocky hillsides and in open woods, not in fields and meadows. There is little that touches the fancy in either 'butter' or 'cup,' but join the two in one word and you have a picture of green pastures sprinkled with gold. The name is an old one. It appears in early English speech, and some authorities would derive it from 'button-cop,' literally 'button-head,' allied to the French *bouton d'or.* 'Butter-cup,' however, has survived, possibly by virtue of its golden chalice, and the name must always be associated with childhood and with spring—with delectable places in the heyday of life. King's-cups and gold-cups are other old names, and cuckoo-buds was still another epithet given to these flowers, for we find it in old dialects and in poetry—

[1] This same religious significance is found in the term 'lady,' or 'ladies,' applied to many plants both in England and America as a corruption of 'Our Lady,' reference being to the Virgin Mary. From a more remote source, in the old pagan mythology, 'Venus' has survived in certain of our plant names—as in Venus slipper (*Cypripedium*), Venus comb, Venus looking-glass, etc.

And cuckoo-buds of yellow hue,
Do paint the meadows with delight,

Shakespeare, however, never once mentions 'buttercup' and we are left to infer the fact that it was buttercups that he had in mind, for it is given as such in old vocabularies. Cuckoo-bud is a charming name, and in England is suggestive of the time of year when the cuckoo begins to sing. But, alas, our American cuckoo is a dismal failure as a vocalist, though his morals are unimpeachable, and we have no good reason for calling flowers after him.[2]

A number of familiar plant names occur in the writings of the old herbalists, as in Gerarde's *Herbal* (1597), and in Parkinson's *Paradisi In Sole* (1629), which contains 'The Garden of Pleasant Flowers.' Here we find such names as crowfoot, toad-flax, snapdragon, columbine, dittany, golden-rod, dog's-tooth violet and many more that sound pleasantly of wayside places. A large class of names are adoptions, applied to plants more or less different from those that bore the original names in England. Thus 'wake robin,' given locally in Great Britain to a species of arum, has been transferred in America to the species of *Trillium*. 'Jack-in-the-box,' a local name of the English arum, appears in America as 'jack-in-the-pulpit,' bestowed upon a closely related plant. Name after name of familiar American herbs and trees may thus be traced back to the provincial speech of England.[3] It might even be possible to trace certain of the settlers back to the district in England from which they emigrated by the local names which they gave to certain plants in America. This at least offers an inviting field for the student of folk-lore.

Of the names that are purely American in origin we have a few well-known examples that have been derived from the Indian peoples. *Puccoon* seems to have been a general name for plants that furnished a juice used by the natives for dyeing and for decorating their bodies. Clayton in the 'Flora Virginica' (1739) thus designates the blood-root (*Sanguinaria*), and it is the common name of several species of gromwell (*Lithospermum*) which yield a yellowish juice, of the yellow-root (*Hydrastis*), and also of the poke-weed (*Phytolacca*) the berries of which stain a deep purple. The word 'poke' is probably a corrup-

[2] A great variety of English wild flowers have been called after the cuckoo, but few if any have survived in American speech. The cuckoo's name appears not only among plants, but in numerous other objects and customs as a survival of old English rural life. Thus, the term 'cuckoo-ale' which is found in provincial dialects, is 'ale drank to welcome the cuckoo's return.' "A singular custom," according to Wright, "prevailed not long ago in Shropshire, that as soon as the first cuckoo had been heard, all the laboring classes left work, and assembled to drink what is called the cuckoo ale." The sweet influence of the hedge-row was evidently close to the heart of these simple country folk.

[3] *Dogwood*, for example, is a name having no reference to the animal, but is derived from the old English *dagge*—a skewer, the wood having been used by butchers for this purpose. *Witch-hazel* has nothing whatever to do with witches, notwithstanding its reputed powers in divination, but is borrowed from the wych-elm, the wood of that tree having been used in making chests called 'wyches.' (Prior.)

tion of the original 'puccoon,' as suggested by Bartlett. 'Hickory' is the Anglicized ending of the Algonquin word *powcohicora* which meant a dish compounded of the kernel of the hickory nut, without reference to the tree itself. Persimmon, sassafras, papaw, catalpa, pipsissewa, pecan, chinquapin, cohosh, maracock (passion flower), kinnikinnik, and others are all more or less garbled forms of aboriginal names. Certain species became known by names suggested from their early association with certain uses or from various peculiarities and properties. Rattlesnake-root and rattlesnake-plantain were greatly esteemed by the native peoples as antidotes for the poison of the reptile. A number of different plants bear the name of 'snake-root,' all of them with supposed virtues in curing the bites of serpents. One of them, the Virginia snake-root (*Aristolochia Serpentaria*), figures in Gerarde's 'Herbal.' "There's the Snake-Root," says Beverley, "so much admired in England for a Cordial, and for being a great Antidote in all Pestilential Distempers." A 'swamp-root' was very early used by the settlers in Virginia for the fever and ague, and the virtues of some plant bearing this name are still exploited, at least in the advertisements of quack doctors. The old chroniclers of America were profound believers in 'simples,' and the early accounts of the country set forth, at considerable length, the medicinal value of various plants. Josselyn, in 'New England's Rarities Discovered,' is a mine of information in this respect. Uses, other than medicinal, have given rise to certain local names. The candle-berry tree—the sweet bay or myrtle of Carolina (*Myrica*)—was so called from the use of its wax-like berries in the making of candles by the settlers. "If an Accident puts a Candle out, it yields a pleasant Fragrancy to all that are in the Room; insomuch, that nice People often put them out, on purpose to have the Incense of the expiring Snuff."

Such names as squaw-root, papoose root, Seneca snake-root, bowman's root, Osage orange, arrowwood, Indian turnip, and the like, have a decided aboriginal flavor and probably hold a story quite as fascinating as any in the Anglo Saxon lineage. Dim pictures of the life of this vanished people will rise before the mind with many of these plant names. The beautiful native orchids of the genus *Cypripedium* that grow in remote woodland places, are called by their Indian name of 'moccasin flower' quite as often as by that which allies them to the old world history of plants and men. In Gray's Manual there is a short sentence that to me has a peculiar and indefinable charm, where wild tobacco is spoken of as occurring in 'old fields from New York westward and southward: a relic of cultivation by the Indians.' What a picture in this brief statement of wigwams in the ancient woods, or in sun-lit clearings, with Indian women hoeing among their maize, squashes, and tobacco!

The effort of the early colonists to give familiar titles to the objects which they found in their new home is apparent in the vernacular names bestowed upon a number of our native birds. It was most natural that a bird so well known and so generally beloved as the English robin-redbreast should find a namesake in America, even though very different in habits and appearance. When the engaging birds with russet breasts came about the New England settlements in early spring, and cheerful pipings sounded through the clearings, 'robin' became a term of welcome and endearment. In some early notices of the bird the entire old world name of robin-redbreast was given. 'Daw' was an early name given to the crow blackbird or purple grackle by the settlers in the Middle Colonies and in Virginia. Though but distantly related to the jackdaw of England, this grackle[4] undoubtedly suggested the name from its habit of gathering in colonies about dwellings, where in the tops of tall pines and other shade trees it builds bulky nests. The jackdaw frequents belfrys and towers, but our blackbird has more of the rook in its nature, although a very different bird both in size and general appearance. The flocking of these grackles about the grounds of country houses and the noise of their vernal clatter is a welcome sign of returning spring. It savors of old homesteads in cultivated lands and suggests ancestral holdings, like the rooks in an English spinney or the daws in castle towers. In this vein of thought Lowell says 'they are the best substitute we have for rooks.' 'Blackbird' could only have been suggested by the generally dark color of the bird seen at a distance and in certain lights. There is nothing about our grackle that is in any way like the English blackbird.

A name is frequently the symbol of some striking characteristic as of color, or peculiarity of voice. Bluebird, redbird, yellow warbler, goldfinch and many others are full of color suggestion, while catbird, chat, phœbe, bobolink, towhee, song sparrow, and the like, appeal to the auditory sense. The bluebird, the nearest we have in this country to the English robin-redbreast and quite as lovable a bird in its way, has found a place in literature as it has in the hearts of all true lovers of the countryside. Alexander Wilson, poet and ornithologist, but first of all a poet, felt the charm of this bird when he immortalized its name in sympathetic prose and verse. The cardinal grosbeak was known as 'redbird' to the Virginia settlers, and, later, when much prized in London as a cage bird, its mellow, whistling notes won for it the title of 'Virginia nightingale.' 'Cardinal' has without doubt come into our language through the French of Louisiana, and possibly also, from the West Indies. The final 'grosbeak' is little used in general talk. I have lately heard some persons speak of this bird as the

[4] We are indebted to science for this word 'grackle' which is an Anglicized form of the Latin *Gracula*—a jack daw, a proof that even the scientific mind was biased in favor of recognizing the distant relationship. The black bird of England is a thrush—the ouzel cock or merle of the old English poets.

'Kentucky Cardinal,' an illustration of the influence of literature in idealizing a thing and making it a part of one's emotional assets.

We have nothing in America that quite takes the place of the English skylark and the nightingale. The mockingbird, the thrasher, the bobolink, the wood thrush, the hermit thrush, and the veery are so entirely different in their songs and their surroundings that comparison of any one of them with either of the foreign birds is impossible. Why our great stalking meadow lark ever became a 'lark,' and not a 'starling' as it should be called, is hard to see, unless its liquid spring notes and its nesting in fields appealed to the early settlers in lieu of any other bird better fitted to bear this glorious name. It seems to be a clear case of name transfer for the sake of the name itself. The catbird is damned by such a title. His summer mewings have played an ugly trick on him, for he is a songster of no mean ability. William Bartram quaintly speaks of his endeavors at imitation, 'even in rehearsing the songs, which he attentively listens to, from the shepherdess and rural swain'—words that call up an Arcadian scene that even Theocritus might have loved; a haunt of Pan in days before the smoke and noise of modern industry sullied the sweet air of fields and groves.

The reader may ask—Why all this pother about names? A name is a name, and, though its history be of passing interest, what need further to talk about it? If literature is the reflection of a people's life the words which give it form and substance are a part of the life itself, at least of its emotional and intellectual reactions. Our appreciation of nature comes so largely through literature, and literature has so greatly extended our sympathy toward things natural, both animate and inanimate, that in this world of words we may be said almost to live and move and have our being. This is the plea that is made for the interest in a name; for the better understanding of the really vital part that it plays in human life.

The past fifty years have seen the growth in America of a remarkable interest in nature, not only in its scientific aspects, but in its esthetic appeal as well. The modern cult of 'nature study' is an expression of this interest and as such is altogether salutary. How much this attitude toward nature is fostered by literature is apparent in the mass of matter that has been and is being written upon the subject. Where one person has reached this state of mind through a sort of primitive instinct that takes him out into direct contact with nature, fifty persons have been led into the same happy state through some appreciative writer like Gilbert White, Richard Jefferies, Thoreau or Burroughs. A truly good book, one that makes its appeal to the heart, calls us into the open where the whole man is refreshed by nature at first hand. In order to read understandingly and sympathetically, one must know the real thing itself, must have had his senses quickened by the thousand influences of wood and field. Then a name will have a meaning to the reader that it never before possessed, and its history will have a meaning when he finds it in the writings of the old world authors. Those of us who are in the middle years of life can remember when our juvenile nature literature was almost entirely English and we became more intimately acquainted with the robin-redbreast and the nightingale, the skylark and the thrush, than we did with our own native birds, whose names were often quite unknown to us. The writings of the English poets and authors from Chaucer down are full of allusions to birds and flowers with which most of us have grown familiar by name only. Shelley's 'Skylark' and Keats' 'Ode to a Nightingale' have made the names living realities to many who have never seen or heard these birds. There are sweet singers in our own country that must take a place in literature, and their names will be doubly dear to the heart through an intimate acquaintance with the birds themselves. One of the most sympathetic of our modern writers has voiced this thought in an exquisite bit of verse—'The Wood-notes of the Veery.'

If two different birds, or two different flowers, in England and America bear the same name, there is no need to cavil, only to recognize the fact that there is a difference. This extension of the name is in itself a source of great interest; it helps to link us to the life and literature of past generations, and in so doing to develop an intelligent and sympathetic understanding. One might have in mind our crow blackbird when reading Tennyson's poem—'The Blackbird,' and fail to see its truth and beauty, simply by not knowing that there are several birds of this name.

> A golden bill! the silver tongue,
> Cold February loved, is dry:
> Plenty corrupts the melody
> That made thee famous once, when young:

No one who knew our blackbird could ever apply this description to him. It more aptly applies to the robin than to any other bird in this country. The golden bill; the silver tongue of our early spring; the corruption of melody when gorged with autumnal fruit; all these are thrush attributes and apply with equal pertinence to both species.

An appreciation of the rightful meaning of a name will go far toward making a true mind picture of the thing itself. A poet like Tennyson was a keen observer of nature, to the slightest detail, and a reader gains the greater pleasure when he divines this quality in the poet's verse. This is not a scientific attitude of mind, not the attitude of a carping critic, but the realization of a certain beauty because of a certain truth—and truth is after all the one thing needful, the only thing that satisfies the soul.

COMPARATIVE PSYCHOLOGY

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COMPARATIVE psychology has arrived. We have had our Descartes and our psychic epiphenomenalists; and their descendants, the vital mechanicians, are still with us. And no Luther has arisen to shatter at a stroke their gods (of tin and other artificers' materials) and proclaim the reformation of psychology in a single revolutionary *coup.* No Darwin has struck off a hypothesis of psychogenesis full grown and puissant to drive its decadent rivals from the field by virtue of its own all-assimilating vitality. But the leaven of Darwinism has been slowly permeating, even into the dusty meal bins of speculative psychology. In spite of fervid anathemas from the citadels of the categorical intuitionalists, the steady growth of genetic ideas has by natural process begun to corrode the very foundations of these strongholds of conservatism; for have we not already begun our natural history of the intuitions and their genesis?

It has been pointed out as a most hopeful sign that this new psychology (unlike that sometimes falsely so called) does not come bearing as its ikons a glittering array of brass instruments of precision and tomes of statistics; but, like the kingdom of Heaven, it cometh not with observation, as a change of mental attitude among both psychologists and naturalists.

There is apparently no general recognition of the revolutionary character of this feature, which is implicit in many movements now current in science and philosophy—movements bearing as diverse labels in the philosophical vernacular of the day as 'experimental evolution,' 'genetic psychology' (in a score of mutually antagonistic forms), 'pragmatism,' 'functional philosophy,' 'paidology,' 'dynamic monism,' etc., etc. So far as the genetic element in these systems is true, it is destined to outlive its ephemeral and sometimes bizarre setting, and the day when we shall have a generally accepted doctrine of psychogenesis and psychic evolution is certainly not far off, though it would be folly to assert that this day has yet dawned.

One of the most valuable features of the remarkable book by Stanley Hall on the psychology of adolescence is the emphasis which he places on the study of the past of mind as a corrective to the morbid speculations on its future which comprise the larger part of the current doctrines of the soul. The ages of psychic evolution through which we have passed have not only cast their shadows down the ranks of time to our own day, but their life is now coursing in our mental pulses as literally as in our corporeal. He goes on to say:

> The best and only key to truly explain mind in man is in the animals he has sprung from and in his own infancy which so faintly recapitulates them; for about every property of the human mind is found in animal mind, as those of higher animals are found in the powers of the lower. . . . The conscious adult person is not a monad reflecting the universe, but a fragment broken off and detached from the great world of soul, always maimed, defined by special limitations, like, yet different from, all others, with some incommensurability parting it off as something unique, well fitted to illustrate some aspects and hopelessly unable to exemplify or even know other regions in the cosmos of soul.

But the trouble is that as soon as a professional philosopher approaches the problems of the cosmic past of mind he is clapped automatically into some metaphysical pigeon hole, whose rigid and often misshapen walls determine that every effort which he puts forth must be molded by past tradition. The very assimilation of the newer data of science, which are the philosopher's meat and drink, involves their incorporation into a metaphysical system already thoroughly organized, and so we read our metaphysics backward through the cosmic process.

The naturalists, accordingly, are calling for a new *Naturphilosophie* which shall be 'anti-metaphysical,' and yet every new such attempt on their own part seems to present more serious metaphysical vices than the preceding. It is obvious that the hope for an anti-metaphysical philosophy is vain, for human philosophic systems flow into metaphysics as the sparks fly upward.

But what shall be the foundation of that metaphysic and the manner of its building is the naturalist's own problem. Shall it be an *a priori* system based upon ancient and mediæval dialectic or shall it be an organic growth whose roots sink deep into the soil of scientific observation and induction? This is a very burning question; for while we can have a practically efficient hod-man type of science without metaphysics, there can be no hope of a future for any metaphysics which is not built up and sustained by the progress of science.

This, of course, can only mean that our metaphysics can not be bound down by the rigid categories of formal logic (which is but a crystallization of the past workings of the human mind); it too must be alive with the lusty vigor of active growth. That such a metaphysic is not unattainable is evident. Certain present tendencies are nothing less than revolutionary in the direction of a really vital metaphysic, and not a few men of science are making their contributions to the same end.

And herein lies the great hope and promise of an immediate fruitfulness in the field of comparative psychology. For the first time in the history of thought, we have both a scientific and a philosophic public sentiment ripe for a serious attempt at a correlation in scientific channels of mental and physical evolution and of mind and body in the broader view.

But how imperfectly are we able to enter into the inner life of even the higher animals whose minds are most like our own! And yet, who knows how many of the powerful, though subconscious springs of our own impulse and motive may lie concealed in inherited vestiges of long-vanished and far more remote ancestral mental powers? Who knows what may be the mental life of a catfish, whose barbels and whole outer body surface are covered with organs of taste and whose gustatory nerves and centers are the biggest in the brain, or of a shark which has an elaborate system of sense organs (the lateral line canals), totally unknown to our own experience, which reach the extreme dimensions of the body and serve as a sort of intermediary apparatus between the organs of touch and the labyrinth of the ear, which is likewise highly developed, though the fish is apparently nearly or quite deaf?

The first task of comparative psychology, then, is to define as accurately as we may with the imperfect means at command the sensori-motor life of the whole range of lower organisms. And this task is fortunately not only approachable, but intrinsically attractive to every lover of nature. The study in field and laboratory of the sensory life of animals, while not all of comparative psychology, is a necessary introduction to its larger correlations and is receiving a rapidly increasing attention by naturalists of all schools; for the development of a true comparative psychology is, as we have seen, bound up with some of the greatest of the current movements in both science and philosophy.

THE VALUE OF SCIENCE

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§ 3. *Tactile Space*

THUS I know how to recognize the identity of two points, the point occupied by A at the instant α and the point occupied by B at the instant β, but only *on one condition*, namely, that I have not budged between the instants α and β. That does not suffice for our object. Suppose, therefore, that I have moved in any manner in the interval between these two instants, how shall I know whether the point occupied by A at the instant α is identical with the point occupied by B at the instant β? I suppose that at the instant α, the object A was in contact with my first finger and that in the same way, at the instant β, the object B touches this first finger; but at the same time, my muscular sense has told me that in the interval my body has moved. I have considered above two series of muscular sensations S and S', and I have said it sometimes happens that we are led to consider two such series S and S' as inverse one of the other, because we have often observed that when these two series succeed one another our primitive impressions are reestablished.

If then my muscular sense tells me that I have moved between the two instants α and β, but so as to feel successively the two series of muscular sensations S and S' that I consider inverses, I shall still conclude, just as if I had not budged, that the points occupied by A at the instant α and by B at the instant β are identical, if I ascertain that my first finger touches A at the instant α and B at the instant β.

This solution is not yet completely satisfactory, as one will see. Let us see, in fact, how many dimensions it would make us attribute to space. I wish to compare the two points occupied by A and B at the instants α and β, or (what amounts to the same thing since I suppose that my finger touches A at the instant α and B at the instant β) I wish to compare the two points occupied by my finger at the two instants α and β. The sole means I use for this comparison is the series Σ of muscular sensations which have accompanied the movements of my body between these two instants. The different imaginable series Σ form evidently a physical continuum of which the number of dimensions is very great. Let us agree, as I have done, not to consider as distinct the two series Σ and $\Sigma + s + s'$, when s and s' are inverses one of the other in the sense above given to this word; in spite of this agreement, the aggregate of distinct series Σ will still form a physical continuum and the number of dimensions will be less but still very great.

To each of these series Σ corresponds a point of space; to two series Σ and Σ' thus correspond two points M and M'. The means we have hitherto used enable us to recognize that M and M' are not distinct in two cases: (1) if Σ is identical with Σ'; (2) if $\Sigma' = \Sigma + s + s'$, s and s' being inverses one of the other. If in all the other cases we should regard M and M' as distinct, the manifold of points would have as many dimensions as the aggregate of distinct series Σ, that is, much more than three.

For those who already know geometry, the following explanation would be easily comprehensible. Among the imaginable series of muscular sensations, there are those which correspond to series of movements where the finger does not budge. I say that if one does not consider as distinct the series Σ and $\Sigma + \sigma$, where the series σ corresponds to movements where the finger does not budge, the aggregate of series will constitute a continuum of three dimensions, but that if one regards as distinct two series Σ and Σ' unless $\Sigma' = \Sigma + s + s'$, s and s' being inverses, the aggregate of series will constitute a continuum of more than three dimensions.

In fact, let there be in space a surface A, on this surface a line B, on this line a point M. Let C_0 be the aggregate of all series Σ. Let C_1 be the aggregate of all the series Σ, such that at the end of corresponding movements the finger is found upon the surface A, and C_2 or C_3 the aggregate of series Σ such that at the end the finger is found on B, or at M. It is clear, first that C_1 will constitute a cut which will divide C_0, that C_2 will be a cut which will divide C_1, and C_3 a cut which will divide C_2. Thence it results, in accordance with our definitions, that if C_3 is a continuum of n dimensions, C_0 will be a physical continuum of $n + 3$ dimensions.

Therefore, let Σ and $\Sigma' + \sigma$ be two series forming part of C_3; for both, at the end of the movements, the finger is found at M; thence results that at the beginning and at the end of the series σ, the finger is at the same point M. This series σ is therefore one of those which correspond to movements where the finger does not budge. If Σ and $\Sigma + \sigma$ are not regarded as distinct, all the series of C_3 blend into one; therefore C_3 will have 0 dimension, and C_0 will have 3, as I wished to prove. If, on the contrary, I do not regard Σ and $\Sigma + \sigma$ as blending (unless $\sigma = s + s'$, s and s' being inverses), it is clear that C_3 will contain a great number of series of distinct sensations; because, without the finger budging, the body may take a multitude of different attitudes. Then C_3 will form a continuum and C_0 will have more than three dimensions, and this also I wished to prove.

We who do not yet know geometry can not reason in this way; we can only verify. But then a question arises; how, before knowing geometry, have we been led to distinguish from the others these series σ where the finger does not budge? It is, in fact, only after having made this distinction that we could be led to regard Σ and $\Sigma + \sigma$ as identical, and it is on this condition alone, as we have just seen, that we can arrive at space of three dimensions.

We are led to distinguish the series σ, because it often happens that when we have executed the movements which correspond to these series σ of muscular sensations, the tactile sensations which are transmitted to us by the nerve of the finger that we have called the first finger, persist and are not altered by these movements. Experience alone tells us that and it alone could tell us.

If we have distinguished the series of muscular sensations $s + s'$ formed by the union of two inverse series, it is because they preserve the totality of our impressions; if now we distinguish the series σ, it is because they preserve *certain* of our impressions. (When I say that a series of muscular sensations s 'preserves' one of our impressions A, I mean that we ascertain that if we feel the impression A, then the muscular sensations s, we *still* feel the impression A *after* these sensations s.)

I have said above it often happens that the series σ do not alter the tactile impressions felt by our first finger; I said *often*, I did not say *always*. This it is that we express in our ordinary language by saying that the tactile impressions would not be altered if the finger has not moved, *on the condition* that *neither has* the object A, which was in contact with this finger, moved. Before knowing geometry, we could not give this explanation; all we could do is to ascertain that the impression often persists, but not always.

But that the impression often continues is enough to make the series σ appear remarkable to us, to lead us to put in the same class the series Σ and $\Sigma + \sigma$, and hence not regard them as distinct. Under these conditions we have seen that they will engender a physical continuum of three dimensions.

Behold then a space of three dimensions engendered by my first finger. Each of my fingers will create one like it. It remains to consider how we are led to regard them as identical with visual space, as identical with geometric space.

But one reflection before going further; according to the foregoing, we know the points of space, or more generally the final situation of our body, only by the series of muscular sensations revealing to us the movements which have carried us from a certain initial situation to this final situation. But it is clear that this final situation will depend, on the one hand, upon these movements and, *on the other hand, upon the initial situation* from which we set out. Now these movements are revealed to us by our muscular sensations; but nothing tells us the initial situation; nothing can distinguish it for us from all the other possible situations. This puts well in evidence the essential relativity of space.

§ 4. *Identity of the Different Spaces*

We are therefore led to compare the two continua C and C' engendered, for instance, one by my first finger D, the other by my second finger D'. These two physical continua both have three dimensions. To each element of the continuum C, or, if you prefer, to each point of the first tactile space, corresponds a series of muscular sensations Σ, which carry me from a certain initial situation to a certain final situation.[1] Moreover, the same point of this first space will correspond to Σ and to $\Sigma + \sigma$, if σ is a series of which we know that it does not make the finger D move.

Similarly to each element of the continuum C', or to each point of the second tactile space, corresponds a series of sensations Σ', and the same point will correspond to Σ' and to $\Sigma' + \sigma'$, if σ' is a series which does not make the finger D' move.

What makes us distinguish the various series designated σ from those called σ' is that the first do not alter the tactile impressions felt by the finger D and the second preserve those the finger D' feels.

Now see what we ascertain: in the beginning my finger D' feels a sensation A'; I make movements which produce muscular sensations S; my finger D feels the impression A; I make movements which produce a series of sensations σ; my finger D continues to feel the impression A, since this is the characteristic property of the series σ; I then make movements which produce the series S' of muscular sensations, *inverse* to S in the sense above given to this word. I ascertain then that my finger D' feels anew the impression A'. (It is of course understood that S has been suitably chosen.)

This means that the series $s + \sigma + s'$, preserving the tactile impressions of the finger D', is one of the series I have called σ'. Inversely, if one takes any series σ', $s' + \sigma' + s$ will be one of the series that we call σ.

Thus if s is suitably chosen, $s + \sigma + s'$ will be a series σ', and by making σ vary in all possible ways, we shall obtain all the possible series σ'.

Not yet knowing geometry, we limit ourselves to verifying all that, but here is how those who know geometry would explain the fact. In the beginning my finger D' is at the point M, in contact with the object a, which makes it feel the impression A'. I make the movements corresponding to the series S; I have said that this series should be suitably

[1] In place of saying that we refer space to axes rigidly bound to our body, perhaps it would be better to say, in conformity to what precedes, that we refer it to axes rigidly bound to the initial situation of our body.

chosen, I should so make this choice that these movements carry the finger D to the point originally occupied by the finger D', that is, to the point M; this finger D will thus be in contact with the object a, which will make it feel the impression A.

I then make the movements corresponding to the series σ; in these movements, by hypothesis, the position of the finger D does not change, this finger therefore remains in contact with the object a and continues to feel the impression A. Finally I make the movements corresponding to the series S'. As S' is inverse to S, these movements carry the finger D' to the point previously occupied by the finger D, that is, to the point M. If, as may be supposed, the object a has not budged, this finger D' will be in contact with this object and will feel anew the impression A'. . . . *Q. E. D.*

Let us see the consequences. I consider a series of muscular sensations Σ. To this series will correspond a point M of the first tactile space. Now take again the two series s and s', inverses of one another, of which we have just spoken. To the series $s + \Sigma + s'$ will correspond a point N of the second tactile space, since to any series of muscular sensations corresponds, as we have said, a point, whether in the first space or in the second.

I am going to consider the two points N and M, thus defined, as corresponding. What authorizes me so to do? For this correspondence to be admissible, it is necessary that if two points M and M', corresponding in the first space to two series Σ and Σ', are identical, so also are the two corresponding points of the second space N and N', that is the two points which correspond to the two series $s + \Sigma + s'$ and $s + \Sigma' + s'$. Now we shall see that this condition is fulfilled.

First a remark. As S and S' are inverses of one another, we shall have $S + S' = 0$, and consequently $S + S' + \Sigma = \Sigma + S + S' = \Sigma$, or again $\Sigma + S + S' + \Sigma' = \Sigma + \Sigma'$; but it does not follow that we have $S + \Sigma + S' = \Sigma$; because, though we have used the addition sign to represent the succession of our sensations, it is clear that the order of this succession is not indifferent: we can not, therefore, as in ordinary addition, invert the order of the terms; to use abridged language, our operations are associative, but not commutative.

That fixed, in order that Σ and Σ' should correspond to the same point $M = M'$ of the first space, it is necessary and sufficient for us to have $\Sigma' = \Sigma + \sigma$. We shall then have: $S + \Sigma' + S' = S + \Sigma + \sigma + S' = S + \Sigma + S' + S + \sigma + S'$.

But we have just ascertained that $S + \sigma + S'$ was one of the series σ'. We shall therefore have: $S + \Sigma' + S' = S + \Sigma + S' + \sigma'$, which means that the series $S + \Sigma' + S'$ and $S + \Sigma + S'$ correspond to the same point $N = N'$ of the second space. *Q. E. D.*

Our two spaces therefore correspond point for point; they can be 'transformed' one into the other; they are isomorphic. How are we led to conclude thence that they are identical?

Consider the two series σ and $S + \sigma + S' = \sigma'$. I have said that often, but not always, the series σ preserves the tactile impression A felt by the finger D; and similarly it often happens, but not always, that the series σ' preserves the tactile impression A' felt by the finger D'. Now I ascertain that it happens *very often* (that is, much more often than what I have just called 'often') that when the series σ has preserved the impression A of the finger D, the series σ' preserves at the same time the impression A' of the finger D'; and, inversely, that if the first impression is altered, the second is likewise. That happens *very often,* but not always.

We interpret this experimental fact by saying that the unknown object a which gives the impression A to the finger D is identical with the unknown object a' which gives the impression A' to the finger D'. And in fact when the first object moves, which the disappearance of the impression A tells us, the second likewise moves, since the impression A' disappears likewise. When the first object remains motionless, the second remains motionless. If these two objects are identical, as the first is at the point M of the first space and the second at the point N of the second space, these two points are identical. This is how we are led to regard these two spaces as identical; or better this is what we mean when we say that they are identical.

What we have just said of the identity of the two tactile spaces makes unnecessary our discussing the question of the identity of tactile space and visual space, which could be treated in the same way.

§ 5. *Space and Empiricism*

It seems that I am about to be led to conclusions in conformity with empiristic ideas. I have, in fact, sought to put in evidence the rôle of experience and to analyze the experimental facts which intervene in the genesis of space of three dimensions. But whatever may be the importance of these facts, there is one thing we must not forget and to which besides I have more than once called attention. These experimental facts are often verified but not always. That evidently does not mean that space has often three dimensions, but not always.

I know well that it is easy to save oneself and that, if the facts do not verify, it will be easily explained by saying that the exterior objects have moved. If experience succeeds, we say that it teaches us about space; if it does not succeed, we hie to exterior objects which we accuse of having moved; in other words, if it does not succeed, it is given a fillip.

These fillips are legitimate; I do not refuse to admit them; but they suffice to tell us that the properties of space are not experimental truths, properly so called. If we had wished to verify other laws, we could have succeeded also, by giving other analogous fillips. Should we not always have been able to justify these fillips by the same reasons? One could at most have said to us: 'Your fillips are doubtless legitimate, but you abuse them; why move the exterior objects so often?'

To sum up, experience does not prove to us that space has three dimensions; it only proves to us that it is convenient to attribute three to it, because thus the number of fillips is reduced to a minimum.

I will add that experience brings us into contact only with representative space, which is a physical continuum, never with geometric space, which is a mathematical continuum. At the very most it would appear to tell us that it is convenient to give to geometric space three dimensions, so that it may have as many as representative space.

The empiric question may be put under another form. Is it impossible to conceive physical phenomena, the mechanical phenomena for example, otherwise than in space of three dimensions? We should thus have an objective experimental proof, so to speak, independent of our physiology, of our modes of representation.

But it is not so; I shall not here discuss the question completely, I shall confine myself to recalling the striking example given us by the mechanics of Hertz. You know that the great physicist did not believe in the existence of forces, properly so called; he supposed that visible material points are subjected to certain invisible bonds which join them to other invisible points and that it is the effect of these invisible bonds that we attribute to forces.

But that is only a part of his ideas. Suppose a system formed of n material points, visible or not; that will give in all $3n$ coordinates; let us regard them as the coordinates of a *single* point in space of $3n$ dimensions. This single point would be constrained to remain upon a surface (of any number of dimensions $< 3n$) in virtue of the bonds of which we have just spoken; to go on this surface from one point to another, it would always take the shortest way; this would be the single principle which would sum up all mechanics.

Whatever should be thought of this hypothesis, whether we be allured by its simplicity, or repelled by its artificial character, the simple fact that Hertz was able to conceive it, and to regard it as more convenient than our habitual hypotheses, suffices to prove that our ordinary ideas, and, in particular, the three dimensions of space, are in no wise imposed upon mechanics with an invincible force.

§ 6. *Mind and Space*

Experience, therefore, has played only a single rôle, it has served as occasion. But this rôle was none the less very important; and I have thought it necessary to give it prominence. This rôle would have been useless if there existed an *a priori* form imposing itself upon our sensitivity, and which was space of three dimensions.

Does this form exist, or, if you choose, can we represent to ourselves space of more than three dimensions? And first what does this question mean? In the true sense of the word, it is clear that we can not represent to ourselves space of four, nor space of three, dimensions; we can not first represent them to ourselves empty, and no more can we represent to ourselves an object either in space of four, or in space of three, dimensions: (1) Because these spaces are both infinite and we can not represent to ourselves a figure *in* space, that is, the part *in* the whole, without representing the whole, and that is impossible, because it is infinite; (2) because these spaces are both mathematical continua and we can represent to ourselves only the physical continuum; (3) because these spaces are both homogeneous, and the frames in which we enclose our sensations, being limited, can not be homogeneous.

Thus the question put can only be understood in another manner; is it possible to imagine that, the results of the experiences related above having been different, we might have been led to attribute to space more than three dimensions; to imagine, for instance, that the sensation of accommodation might not be constantly in accord with the sensation of convergence of the eyes; or indeed that the experiences of which we have spoken in paragraph 2 and of which we express the result by saying 'that touch does not operate at a distance,' might have led us to an inverse conclusion.

And *then evidently yes* that is possible. From the moment one imagines an experience, one imagines just by that the two contrary results it may give. That is possible, but that is difficult, because we have to overcome a multitude of associations of ideas, which are the fruit of a long personal experience and of the still longer experience of the race. Is it these associations (or at least those of them that we have inherited from our ancestors), which constitute this *a priori* form of which it is said that we have pure intuition? Then I do not see why one should declare it refractory to analysis and should deny me the right of investigating its origin.

When it is said that our sensations are 'extended' only one thing can be meant, that is that they are always associated with the idea of certain muscular sensations, corresponding to the movements which enable us to reach the object which causes them, which enable us, in other words, to defend ourselves against it. And it is just because this association is useful for the defense of the organism, that it is so old in the history of the species and that it seems to us indestructible. Nevertheless, it is only an association and we can conceive that it may be broken; so that we may not say that sensation can not enter consciousness without entering in space, but that in fact it does not enter consciousness without entering in space, which means, without being entangled in this association.

No more can I understand one's saying that the idea of time is logically subsequent to space, since we can represent it to ourselves only under the form of a straight line; as well say that time is logically subsequent to the cultivation of the prairies, since it is usually represented armed with a scythe. That one can not represent to himself simultaneously the different parts of time, goes without saying, since the essential character of these parts is precisely not to be simultaneous. That does not mean that we have not the intuition of time. So far as that goes, no more should we have that of space, because neither can we represent it, in the proper sense of the word, for the reasons I have mentioned. What we represent to ourselves under the name of straight is a crude image which as ill resembles the geometric straight as it does time itself.

Why has it been said that every attempt to give a fourth dimension to space always carries this one back to one of the other three? It is easy to understand. Consider our muscular sensations and the 'series' they may form. In consequence of numerous experiences, the ideas of these series are associated together in a very complex woof, our series are *classed*. Allow me, for convenience of language, to express my thought in a way altogether crude and even inexact by saying that our series of muscular sensations are classed in three classes corresponding to the three dimensions of space. Of course this classification is much more complicated than that, but that will suffice to make my reasoning understood. If I wish to imagine a fourth dimension, I shall suppose another series of muscular sensations, making part of a fourth class. But as *all* my muscular sensations have already been classed in one of the three preexistent classes, I can only represent to myself a series belonging to one of these three classes, so that my fourth dimension is carried back to one of the other three.

What does that prove? This: that it would have been necessary first to destroy the old classification and replace it by a new one in which the series of muscular sensations should have been distributed into four classes. The difficulty would have disappeared.

It is presented sometimes under a more striking form. Suppose I am enclosed in a chamber between the six impassable boundaries formed by the four walls, the floor and the ceiling; it will be impossible for me to get out and to imagine my getting out. Pardon, can you not imagine that the door opens, or that two of these walls separate? But of course, you answer, one must suppose that these walls remain immovable. Yes, but it is evident that I have the right to move; and then the walls that we suppose absolutely at rest will be in motion with regard to me. Yes, but such a relative motion can not be anything; when objects are at rest, their relative motion with regard to any axes is that of a rigid solid; now, the apparent motions that you imagine are not in conformity with the laws of motion of a rigid solid.

Yes, but it is experience which has taught us the laws of motion of a rigid solid; nothing would prevent our *imagining* them different. To sum up, for me to imagine that I get out of my prison, I have only to imagine that the walls seem to open, when I move.

I believe, therefore, that if by space is understood a mathematical continuum of three dimensions, were it otherwise amorphous, it is the mind which constructs it, but it does not construct it out of nothing; it needs materials and models. These materials, like these models, preexist within it. But there is not a single model which is imposed upon it; it has *choice;* it may choose, for instance, between space of four and space of three dimensions. What then is the rôle of experience? It gives the indications following which the choice is made.

Another thing: whence does space get its quantitative character? It comes from the rôle which the series of muscular sensations play in its genesis. These are series which may *repeat themselves,* and it is from their repetition that number comes; it is because they can repeat themselves indefinitely that space is infinite. And finally we have seen, at the end of section 3, that it is also because of this that space is relative. So it is repetition which has given to space its essential characteristics; now, repetition supposes time; this is enough to tell that time is logically anterior to space.

§ 7. *Rôle of the Semicircular Canals*

I have not hitherto spoken of the rôle of certain organs to which the physiologists attribute with reason a capital importance, I mean the semicircular canals. Numerous experiments have sufficiently shown that these canals are necessary to our sense of orientation; but the physiologists are not entirely in accord; two opposing theories have been proposed, that of Mach-Delage and that of M. de Cyon.

M. de Cyon is a physiologist who has made his name illustrious by important discoveries on the innervation of the heart; I can not, however agree with his ideas on the question before us. Not being a physiologist, I hesitate to criticize the experiments he has directed against the adverse theory of Mach-Delage; it seems to me, however, that they are not convincing, because in many of them the *total* pressure was made to vary in one of the canals, while, physiologically, what varies is the *difference* between the pressures on the two extremities of the canal; in others the organs were subjected to profound lesions, which must alter their functions.

Besides, this is not important; the experiments, if they were irreproachable, might be convincing against the old theory. They would not be convincing *for* the new theory. In fact, if I have rightly understood the theory, my explaining it will be enough for one to understand that it is impossible to conceive of an experiment confirming it.

The three pairs of canals would have as sole function to tell us that space has three dimensions. Japanese mice have only two pairs of canals; they believe, it would seem, that space has only two dimensions, and they manifest this opinion in the strongest way; they put themselves in a circle, and, so ordered, they spin rapidly around. The lampreys, having only one pair of canals, believe that space has only one dimension, but their manifestations are less turbulent.

It is evident that such a theory is inadmissible. The sense-organs are designed to tell us of *changes* which happen in the exterior world. We could not understand why the Creator should have given us organs destined to cry without cease: Remember that space has three dimensions, since the number of these three dimensions is not subject to change.

We must, therefore, come back to the thory of Mach-Delage. What the nerves of the canals can tell us is the difference of pressure on the two extremities of the same canal, and thereby: (1) the direction of the vertical with regard to three axes rigidly bound to the head; (2) the three components of the acceleration of translation of the center of gravity of the head; (3) the centrifugal forces developed by the rotation of the head; (4) the acceleration of the motion of rotation of the head.

It follows from the experiments of M. Delage that it is this last indication which is much the most important; doubtless because the nerves are less sensible to the difference of pressure itself than to the brusque variations of this difference. The first three indications may thus be neglected.

Knowing the acceleration of the motion of rotation of the head at each instant, we deduce from it, by an unconscious integration, the final orientation of the head, referred to a certain initial orientation taken as origin. The circular canals contribute, therefore, to inform us of the movements that we have executed, and that on the same ground as the muscular sensations. When, therefore, above we speak of the series S or of the series Σ, we should say, not that these were series of muscular sensations alone, but that they were series at the same time of muscular sensations due to the semicircular canals. Apart from this addition, we should have nothing to change in what precedes.

In the series S and Σ, these sensations of the semicircular canals evidently hold a very important place. Yet alone they would not suffice, because they can tell us only of the movements of the head; they tell us nothing of the relative movements of the body, or of the members in regard to the head. And more, it seems that they tell us only of the rotations of the head and not of the translations it may undergo.

NOBEL MEDALS

The gold medals conferred in connection with the Nobel prizes are here shown. Above is the medal in physics and in chemistry. The obverse of the medals in medicine and in literature is the same; the reverse of each of these medals is shown beneath. At the bottom is the medal for the promotion of peace.

THE PROGRESS OF SCIENCE

THE NOBEL PRIZES

THE great prizes established by the will of Alfred Nobel were awarded for the sixth time on December 10, the anniversary of the death of the founder, as follows: Physics, Professor J. J. Thomson of Cambridge; chemistry, M. Moissan of Paris; medicine, Professor S. Ramón y Cajal of Madrid and Professor Camillo Golgi of Pavia; literature, Professor Giosuè Carducci of Bologna; for the promotion of peace among nations, President Roosevelt. These international awards, of the value of about $40,000, are of sufficient magnitude not only to be of interest to scientific men, but also to attract the attention of the civilized world. They are thus a real factor in increasing the dignity of the scientific career and in encouraging scientific work.

Regret has already been expressed here that the confidence placed by Nobel in his native land has not been justified. His large fortune was made in Great Britain by the discovery and manufacture of dynamite, and it seems likely that the instructions of his will would have been more adequately carried out if their execution had been entrusted to the Royal Society and the British courts. Nobel doubtless believed that the international obligations would be fully met by the Scandinavian countries, and it is truly sad and discouraging that there should be lack of good faith in the administration of a fund intended as the testator states 'to benefit mankind.'

Nobel's will is perfectly clear and explicit. It directs that the interest from the fund 'shall be divided into five equal parts,' which shall be annually awarded in prizes to those persons who shall have contributed most materially to benefit mankind during the year immediately preceding. "One share to the person who shall have made the most important discovery or invention in the domain of physics; one share to the person who shall have made the most important chemical discovery or improvement; one share to the person who shall have made the most important discovery in the domain of physiology or medicine; one share to the person who shall have produced in the field of literature the most distinguished work of an idealistic tendency, and, finally, one share to the person who shall have most or best promoted the fraternity of nations and the abolishment or diminution of standing armies and the formation and increase of peace congresses."

In face of these explicit directions statutes have been drawn up, apparently with the sanction of the King of Sweden and others high in authority, providing that only sixty per cent. of the income need be used for the prizes and that they need be awarded only once in five years. The balance of the income—except perhaps in the case of the prize for the promotion of peace, regarding which information is lacking—is now used for the support of certain laboratories and libraries at Stockholm. These are doubtless needed, possibly more than the prizes established by Nobel, but they have been founded in dishonor. The clause establishing the laboratory of physics and chemistry is unpleasantly disingenuous. It says that it is to be "established primarily for the purpose of carrying out, where the respective Nobel committees shall deem requisite, scientific investigation as to the value of those discoveries in the domains of physics and chemistry which shall have been proposed as meriting the award of Nobel prize to their authors. The institute shall, moreover, as far as its means allow, promote such researches in the domains of the sciences named as promise to result in salient advantage." The prizes have so far been awarded annually, but it is to be feared that when the money is needed in Sweden, it will be kept there in accordance with the provision of the statutes that when a prize is not awarded the money may be used for funds 'to promote the objects which the testator ultimately had in view in making his bequest in other ways than by means of prizes.'

The administrators of the Nobel foundation have violated the conditions of the bequest in other ways which, though not so discreditable as the conveying of the money to local purposes and men, can not be regarded as justifiable. Nobel expressly stipulates that the prizes shall be awarded to those "who shall have contributed most materially to benefit mankind during the year immediately preceding." The statutes hedge, as follows: "By the proviso in the will to the effect that for the prize competition only such works or inventions shall be eligible as have appeared 'during the preceding year' is to be understood that a work or invention for which a reward under the terms of the will is contemplated shall set forth the most modern results of work being done in that of the departments, as defined in the will, to which it belongs; works or inventions of older standing to be taken into consideration only in case their importance has not previously been demonstrated."

In no single case has the award been made for work accomplished or published during the preceding year. The prizes have been given to men of eminence, most of whom accomplished their important work long ago. It would certainly be difficult to select each year the work most beneficial to mankind, and mistakes would undoubtedly be made; but the effort to make such a selection and to award the prize without regard to nationality, age or eminence would be a great stimulus to research, far greater probably than the methods adopted. But the question is not which method is the better, but for what purposes Nobel made his bequest. The terms of the will have also been violated by dividing the prizes and by awarding them to institutions, and its spirit has been especially ignored by giving the power of nomination and determination chiefly to Swedes. It does not of course follow that the dead hand should forever control. But Nobel died only ten years ago. He might be given his will for a little while at least, and under the special circumstances of the case it would seem only just to submit any provisions which proved impracticable or unwise to international consideration.

There is a certain lack of courtesy in thus criticizing actions sanctioned by the Swedish government and by those Swedish men of science at least who are accepting gratuities from the fund. Neither can we as a nation regard ourselves as fit to cast stones when we remember the histories of the Stewart, Tilden and other bequests, or when we consider that the Smithsonian Institution, established by a foreigner 'for the increase and diffusion of knowledge among men' has been used largely for the promotion of local interests. But it is only by frankly considering these things that we may learn that honor is more than great riches.

THE SCIENTIFIC MEETINGS OF CONVOCATION WEEK

The American Association for the Advancement of Science and the national scientific societies affiliated with it hold their annual meeting this year in New York City, beginning on December 27. Washington and New York

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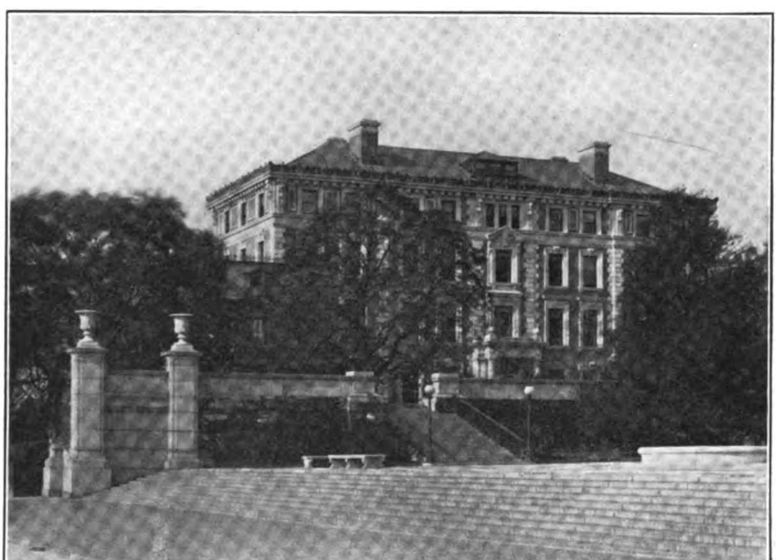
are now our two main scientific centers, there being in each city about five hundred men engaged in research work. The first of the convocation week meetings was held in Washington four years ago, with an attendance estimated at 1,500 members, and there is good reason to suppose that the present meeting will be even larger and more wide reaching in its effects on the



THE SCHOOL OF MINES, COLUMBIA UNIVERSITY. This building has just been completed. In the foreground is the house used by the Faculty Club.

EARL HALL, COLUMBIA UNIVERSITY. This building is the headquarters of the American Association and the affiliated societies.

advancement and diffusion of science.

It is not possible in this note to give a statement even of the main features of the programs. The American Association meets in ten sections, each with its own presiding officers and its program of papers and discussions lasting several days. There are further about twenty national societies which meet in affiliation, sometimes holding joint sessions with the sections of the association or with one another and sometimes meeting separately. These societies, which include those devoted to astronomy, physics, mathematics, chemistry, geology, geography, zoology, entomology, bacteriology, physiology, anatomy, botany, psychology, philosophy and anthropology, each has its independent organization and officers, so it is obvious that the programs are extensive. There will be at least five hundred papers read, which when published in detail will fill more than ten thousand pages.

The high character and broad interest of the proceedings may be briefly but adequately shown by a list of some of the retiring or presiding officers, most of whom will make addresses. Every one familiar with science in America will understand that they represent the best work now being accomplished. These officers include: Professor W. H. Welch of the Johns Hopkins University, Professor C. M. Woodward of Washington University, Professor William James of Harvard University, Professor Charles B. Davenport of the Cold Spring Biological Laboratory, Professor E. C. Pickering of the Harvard College Observatory, Professor Carl Barus of Brown University, Professor W. F. Osgood of Harvard University, Dr. W. F. Hillebrand of the U. S. Geological Survey, Mr. C. C. Adams of New York City, Professor W. E. Castle of Harvard University, Mr. A. H. Kirtland of Malden, Mass., Professor Erwin F. Smith of the U. S. Department of Agriculture, Professor W. H. Howell of the Johns Hopkins University, Professor Franklin P. Mall of the Johns Hopkins University, Dr. F. S. Earle of Herradura, Cuba, Professor J. R. Angell of the University of Chicago, Professor F. W. Putnam of Harvard University, Professor John F. Woodhull of Teachers' College, Columbia University, Professor Edward Kasner of Columbia University, Professor W. C. Sabine of Harvard University, Mr. Clifford Richardson of New York City, Mr. W. R. Warner of Cleveland, Ohio, Dr. A. C. Lane of the Michigan Geological Survey, Professor

Edwin G. Conklin of the University of Pennsylvania, Dr. D. T. MacDougal of the Carnegie Institution, Mr. Charles A. Conant of New York City, and Dr. Simon Flexner of the Rockefeller Institute for Medical Research.

Most of the meetings will be held at Columbia University, but there will also be sessions at the American Museum of Natural History, The Rockefeller Institute for Medical Research, the College of the City of New York, the New York Botanical Garden and elsewhere. These and other scientific institutions of the city have in recent years made extraordinary progress. There is here only space to show several of the buildings of Columbia University, which, having removed to its new site overlooking the city of New York only ten years ago, has now a group of academic buildings in many respects unequalled.

THE OPSONIC INDEX OF WRIGHT AND DOUGLAS

SIR ALMROTH E. WRIGHT, M.D., F.R.S., pathologist to St. Mary's Hospital, London, and late professor of pathology, Army Medical School, Netley, delivered the third course of lectures on the Herter foundation in the Physiological Building of Johns Hopkins Medical School on October 8, 9 and 10, 1906. The subject chosen was 'The therapeutic inoculation of bacterial vaccines and its application in connection with the treatment of bacterial disease.' As this subject is an important elaboration of Metchnikoff's work upon phagocytosis and of Ehrlich's side-chain theory, it may not be out of place briefly to outline from these lectures Wright's method and to cite a few illustrative cases showing the value of this mode of procedure in the treatment of certain bacterial diseases by vaccines.

The term opsonin, meaning 'to prepare for a meal,' is given to a recently discovered and important constituent of both normal and immune sera, by means of which bacteria are prepared for phagocytosis. The method of determining the opsonic index is as follows: About five cubic centimeters of blood is withdrawn from a healthy person under aseptic conditions by pricking the finger. This blood is then placed in a glass tube (*A*), slightly heated to facilitate clotting, and centrifugalized so as to separate the serum from the clot. In a second tube (*B*) is placed about the same amount of blood, to which is added sodium-citrate solution in order to prevent clotting. By centrifugalizing this there are obtained three layers, *i. e.*, serum, white corpuscles and red corpuscles. The serum it pipetted off and the solution containing leucocytes at once becomes easily accessible. A third tube (*C*) contains an aqueous solution of tubercle bacilli. This is also centrifugalized in order to get a fine suspension. Equal quantities of the serum of a healthy person (*A*); of white blood corpuscles (*B*); and of a tubercle bacilli solution (*C*) are drawn into a capillary tube and freely mixed. They are then placed in an incubator for twenty minutes. A film is next made and stained by any of the well-known methods of staining for tubercle bacilli. Then the exact number of bacilli found to be present in thirty consecutive multinuclear leucocytes are counted by the aid of an oil-immersion lens—call it in this case *X*. The process is now repeated, substituting the blood of a patient for the blood of the healthy person, the white corpuscles and aqueous tubercle solution remaining constant in both estimations. The result obtained by counting these latter may be called *Y*; in that case the opsonic index of the patient's blood is expressed thus, Y/X, which is usually a decimal. The entire process occupies about one hour and a quarter in the hands of an experienced laboratory worker.

The surgeon's idea of curing bacterial diseases, such as scrofulous glands of the neck, seems too often to be that of extirpation, though he does often employ instead of the knife various recent methods of treatment, such as Röntgen rays, Finsen's light, radium and Bier's passive hyperæmia. The ideal treatment, however, of bacterial disease is to put into the blood a substance, like an antiseptic, which will kill the bacteria or neutralize their toxines, but which will not injure the tissues with which it is brought in contact. This has been done to a certain extent by the antitoxin of diphtheria, but there has not been discovered, up to the present time, a scientific and exact method by means of which the therapeutic use of such agents as tuberculin could be controlled in order that the smallest amount of detriment possible might ensue to the patient during the course of the treatment. That there exists a certain substance in the serum of the blood which is capable of aiding phagocytosis, is shown by the history of a case cited by Wright in which there was a condition of furunculosis (boils) due to *staphylococci*. The patient's serum, his corpuscles and an emulsification of dead *staphylococci* gave a count of 26; while the patient's serum, the corpuscles from a normal person and the emulsion, gave 27; the normal serum, the normal corpuscles and the emulsion, gave 13; the normal serum, the patient's corpuscles and the emulsion also giving 13. This would show that the corpuscular elements had nothing to do with the increased number of *staphylococci* which were taken up by the leucocytes and would show that the property of increasing the number of *staphylococci* in the leucocytes is to be attributed to the so-called opsonin in the serum itself.

By using this index after the injection of the vaccine, it will be seen that there is usually a slight decrease in the opsonic index, followed by a marked secondary rise; though if the dose be too large or a second dose be administered too quickly, this secondary rise may not occur at all. The interesting fact was brought out by Wright in his lectures that a surgical operation, or even massage, or sitting up in bed, may cause a similar reaction in a tuberculous foci. The disadvantage of securing the reaction by these methods is that live tubercle bacilli may be introduced into the blood stream and that their lodgment and subsequent multiplication may take place. Dr. Wright is so sanguine of the success of this mode of treatment that he believes that every case of *localized* tuberculosis may be now cured by the *proper* use of the vaccines of tuberculosis.

SCIENTIFIC ITEMS

A MEETING to commemorate the life and service of Samuel Pierpont Langley, secretary of the Smithsonian Institution from 1887 to 1906, was held in the lecture room of the United States National Museum on December 3. The following addresses were delivered: 'Introductory Remarks,' by the chancellor of the Smithsonian Institution, the Honorable Melville W. Fuller, chief justice of the United States; 'Memorial on Behalf of the Board of Regents,' by the Honorable Andrew D. White, LL.D.; 'Mr. Langley's Contributions to Astronomy and Astrophysics,' by Professor E. C. Pickering, director of the Harvard College Observatory; 'Mr. Langley's Contributions to Aerodynamics,' by Octave Chanute, Esq., of Chicago.

DR. HENRY FAIRFIELD OSBORN, Da Costa professor of zoology in Columbia University, curator of vertebrate paleontology and vice-president of the American Museum of Natural History, geologist and paleontologist of the U. S. Geological Survey, has declined the secretaryship of the Smithsonian Institution to which he was elected by the regents on December 4.—Dr. Andrew Fleming West, professor of Latin at Princeton University and dean of the graduate school, has declined the offer of the executive committee of the Massachusetts Institute of Technology to nominate him for the presidency.

Edw L Nichols 1906

PROFESSOR OF PHYSICS, CORNELL UNIVERSITY, PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

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GLACIAL EROSION IN ALASKA[1]

BY PROFESSOR RALPH S. TARR
CORNELL UNIVERSITY

WHEN Henry Gannett made the statement that "thousands of cubic miles" of rock had been removed from the fiords of southeastern Alaska by glacial erosion, and that "the relief features of this region, its mountains and its gorges partly filled by the sea, are all of glacial origin,"[2] it is probable that many readers had the feeling that he had greatly exaggerated the case of glacial erosion. For my own part, I distinctly remember reading this with the feeling that, although glaciers are unquestionably capable of doing great work of erosion, it would require the most convincing evidence to satisfy me of even the approximate accuracy of this statement. Having now made four trips over a part of the route upon which Mr. Gannett based his statements, and having examined the phenomena attentively, there and elsewhere, I have the conviction that in reality his statement of the case is in close harmony with the truth. It is the purpose of this paper to state the argument upon which this conclusion is based.

It is a well-known fact that it is possible to go from Seattle to Sitka, along a series of 'Channels,' 'Canals' and 'Reaches' without once entering the open ocean. In addition to this unique 'Inside Passage' of upwards of 1,000 miles, there is a maze of branches of such enormous extent that the whole system of channels has not yet been charted. Everywhere these arms of the sea are enclosed between

[1] Published by permission of the Director of the U. S. Geological Survey. I am indebted to Lawrence Martin and O. von Engeln, members of my expeditions, for photographic work, as indicated under the illustrations, and to Mr. Martin and B. S. Butler for valuable assistance in my field investigations.

[2] Harriman Alaska Expedition, Vol. II., History, Geography, Resources, 1902, pp. 258–259.

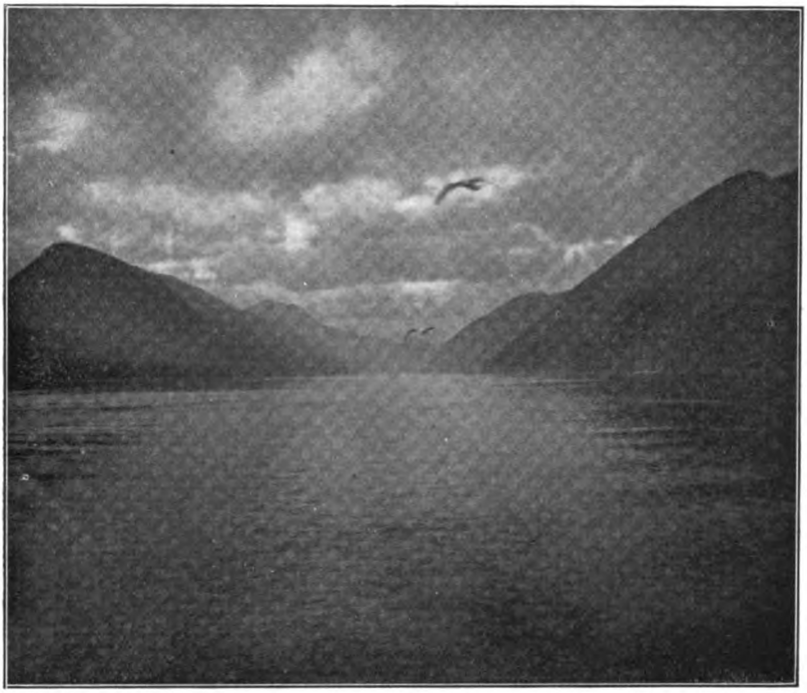

FIG. 1. ALIGNED SPURS, INSIDE PASSAGE. Three such spurs seen on the right, the most distant one showing the change in slope. Two shown on the left, with the change in slope plainly visible in the more distant one. From such a condition as this there is every gradation to straight walled 'canals' Photograph by O. von Engeln.

mountain walls, and in many places they have the characteristics of grand fiords.

Such a topography as this has, until recently, been quite generally explained as a result of subsidence of the land, by which the lower ends of the land valleys have been drowned by the admission of the sea water into them. In this way the irregular coast of Patagonia, the fiords of Norway, and other similar coast lines have been explained.

Under ordinary conditions, the development of valleys by stream erosion produces certain characteristic features which are easily recognizable. These features are well understood by physiographers and have been fully stated on many occasions, and especially by Professor Davis, to whom, more than to any other, we owe our clear recognition of them and their application to the problems of glacial erosion.

One of these features is the cross-section of the valley, which varies in width and steepness according to the stage of its development. A young stream valley is steep-sided and gorge-like. Its width is narrow in proportion to its depth. A mature valley, having long been exposed to action of the weather, has been broadened out by the weathering back of the valley walls so that its width is great as compared with its depth. For a stream valley to pass from youth to maturity, even under the most favorable conditions, requires a great lapse of time.

The form of river valley to be expected in such a mountainous country as the coast of British Columbia and Alaska, would therefore depend largely upon the length of time that the streams had been working to cut the valleys. Had the stream action been brief, we should expect to find profound gorges; had it been long, broader valleys and the more gentle slopes of maturity. If, as is the case in Alaska, the same valleys have some of the characteristics of youth and some of maturity, a special explanation must be sought.

A second characteristic which results from the normal development of stream valleys is the accordance in grade between main and tributary streams. No matter how fast the main stream may be lowering its valley, even though it be a Colorado River, the side streams, including even weak tributaries, lower their mouths at approximately the same rate that the main stream deepens its valley. This feature is so well established as a normal condition of valley development, that it may be stated as a law that, under normal conditions of stream development, tributary valleys enter main valleys approximately at grade. That this is not the case in many instances in Alaska will be shown below.

A third feature normally developed during the formation of stream valleys is that of a somewhat winding course with overlapping spurs, alternating first on one side then on the other. Because of this

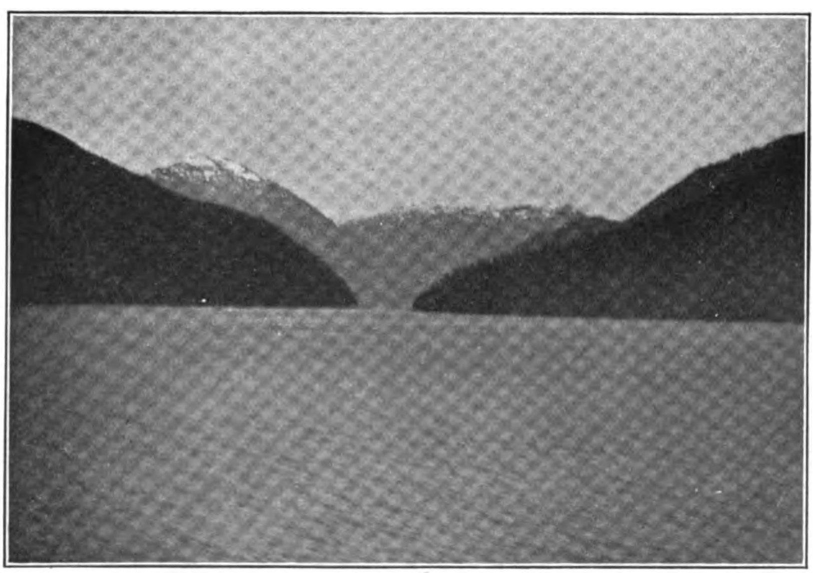

FIG. 2. LARGE TRIBUTARY VALLEY ENTERING GRENVILLE CHANNEL FROM THE EAST, BELOW THE SEA LEVEL. Note steepened lower slope on left side of tributary valley. Photograph by Lawrence Martin.

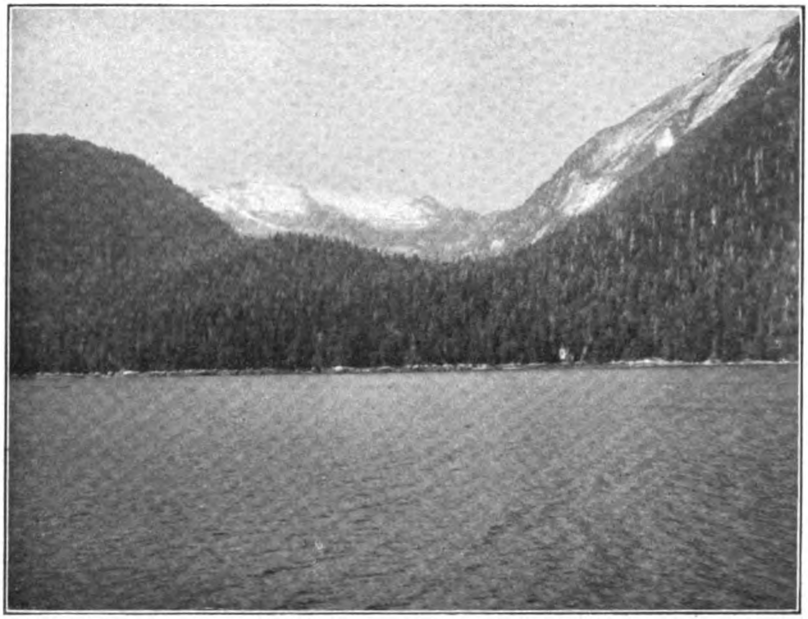

Fig. 3. Hanging Valley in Grenville Channel, Inside Passage. Waterfall of stream draining the broad, U-shaped valley seen near water in right-hand half of picture. Photograph by Lawrence Martin.

feature a view up or down such a valley is not usually very extensive, being cut off by the projecting spurs around which the stream swings. The absence of this feature in those Alaskan valleys where there is a

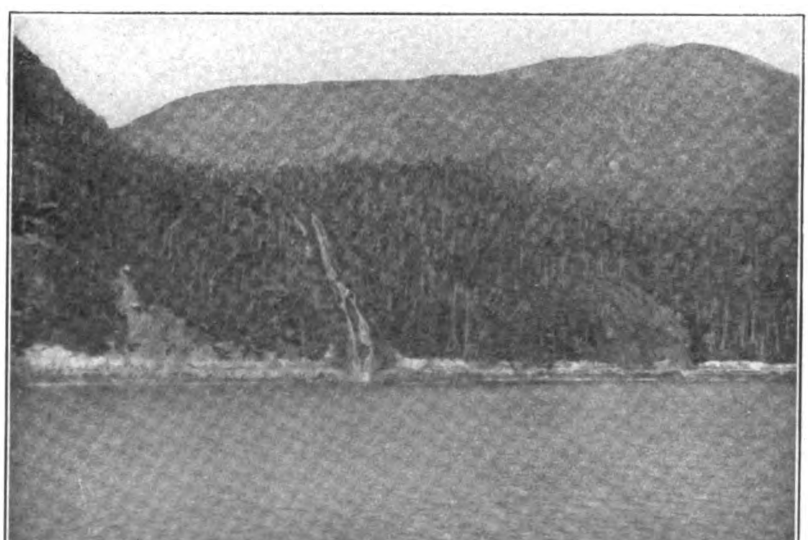

Fig. 4. Waterfall on the Very Face of the Rock Lip of a Hanging Valley behind Sara Island, Inside Passage. Photograph by Lawrence Martin.

discordance in the other directions mentioned above, calls for explanation.

The partial submergence of a region traversed by a series of valleys with the characteristics just stated, would produce results which can be readily and accurately predicted. The line up to which the new sea level reached would be rendered irregular for two reasons. In the first place, the overlapping spurs would introduce a winding coast line in the fiords, with capes on one side opposite reentrants on the other. In the second place, since the tributary valleys joined the main valleys at grade, the sea water would enter their mouths and thus transform their lower portions to bays.

Examining the actual conditions along the Inside Passage to Alaska, we find very wide departures from this postulated result of a drowning of normal land valleys. Many of the passages are in the form of long straight 'Reaches' and 'Canals,' up and down which one can look for miles without obstruction to the view. In other cases the 'Reaches,' though not perfectly straight, have alternating projections and reentrants (Fig. 1). These, however, depart from typical overlapping spurs in two important respects. In the first place, they are much less pronounced. In the second place, instead of having a uniform slope from the crest to the tip of the spurs, they have a moderate slope above, like that of ordinary valley spurs, but terminate on the water side in a steep and even precipitous slope. They have the appearance, therefore, of being *truncated* valley spurs; and a view through such a channel often shows a succession of these partial spurs with the truncated faces in alignment. The general appearance of these aligned spurs suggests that some powerful rasping agent has moved through the fiord and truncated the overlapping spurs back to a fairly uniform distance.

The fiords of the Inside Passage furnish all gradations from typical overlapping spurs to aligned spurs, and to straight, smoothed 'Canals' from which all semblance of spurs has been erased. In the latter case the valley walls themselves often possess a double slope, steep and even precipitous below, more gentle above. The steepened lower slope has the appearance of having been incised in a valley whose remnant is represented by the upper more gentle slope.

In those 'Reaches' which are long and straight, and in those with aligned spurs, the tributary valleys enter the main valley at very different levels. Some, especially the larger, enter below the level of the sea, and in these cases there are bays in their mouths (Fig. 2); many others have their mouths high above the fiord level (Figs. 3, 4 and 5). Although there is no uniform height at which these side valleys enter the main trough, in general it is true that, the smaller the tributary valley, the higher its mouth lies above the main valley bottom. These are called *hanging valleys* because their mouths hang above the bottom

FIG. 5. HANGING VALLEY, GRENVILLE CHANNEL, INSIDE PASSAGE. The forest-covered lip is solid rock, but it looks like a dam. Doubtless if one went to the crest of this lip he would find the broad valley extending, with moderate grade up the distant mountain. Note the waterfall near center of picture. Photograph by Lawrence Martin.

of the main valley to which they are tributary, instead of entering at grade, as is normal.

Where these Alaskan hanging valleys are most typically developed, the appearance is quite remarkable. The valley wall of the long, straight 'Reach' or 'Canal' is broken by a broad U-shaped tributary valley, whose cross section, if explained by ordinary methods of valley formation, would require a long period of time for its formation. The stream occupying the hanging valley flows with moderate grade up to the point where the tributary valley is intersected by the straight wall of the main 'Reach.' Then, instead of continuing into the main valley with the same grade, it tumbles over the lip of the hanging valley and descends to the fiord in a succession of leaps, sometimes on the very face of the main valley wall (Fig. 4), sometimes in a shallow gorge (Figs. 3 and 5).

In these most typical cases, there is such an absolute discordance of conditions as to cause comment from even the most casual observers, as I had occasion to observe in many instances in sailing through the Inside Passage. The first feature to attract attention was the waterfall. It was then noticed that the stream emerged from a broad valley, far up which one could look, though without seeing its bottom (Figs. 3–5). This produced the impression that the lip of the hanging valley was really a dam across the mouth of a broad tributary valley.

This deceptive appearance was so striking that, on asking fellow voyagers for an explanation of the hanging valleys, I have again and again received the answer that the mouth of the valley has been dammed and a lake formed behind it. So apparent is this explanation that the captain of the steamer stated positively that there are always lakes behind these lips.

Thus the hanging valley is so abnormal a feature that even to ordinary observers it seems to demand some special explanation. That there are lakes in some of the hanging valleys is probable; but it is not a necessary condition. The lip is not a dam; it is unconsumed rock in a valley bottom that has been left high above the main valley by exceptional conditions which have deepened the main trough. It was of course impossible to stop and go into the many hanging valleys which we passed in the Inside Passage, but farther up the coast I was able to enter such valleys and prove, what I was well aware of before, that the lip is not a dam and that lakes form no necessary part of the hanging-valley condition (see Figs. 7 and 8).

Two other features of the valleys in the Inside Passage are noteworthy. One is the fact that in both the main and tributary valleys the rock walls have been smoothed and rounded by glacial action, proving the former extension of glaciers through this series of 'Reaches.' The other is the remarkably uniform cross-section of both the main and tributary valleys, as is so well illustrated in many of the accompany-

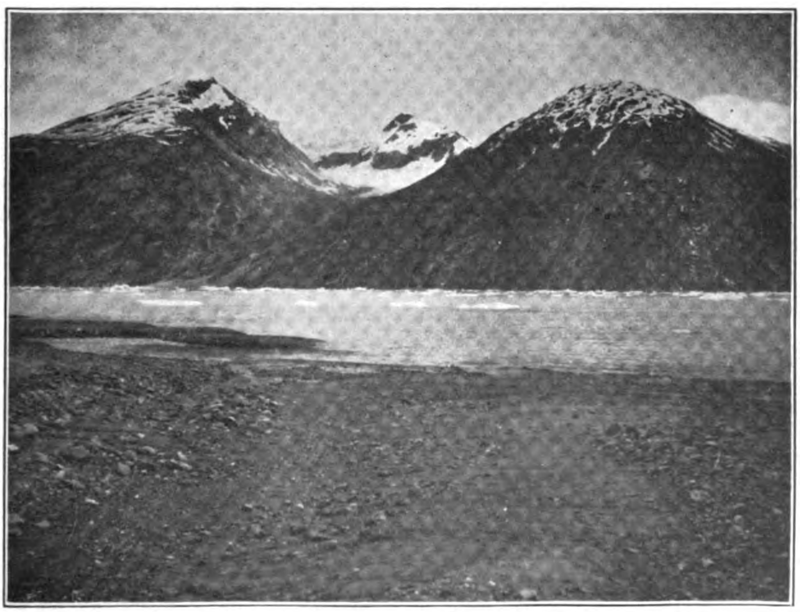

FIG. 6. A HANGING VALLEY ON THE SOUTH SIDE OF NUNATAK FIORD. This valley lies on the same side, but about a mile west of the succeeding pictures (Figs. 7, 8 and 9). The floating ice is from Nunatak glacier about four miles distant. Photograph by Lawrence Martin.

ing photographs. They are distinctly U-shaped with smooth and regular walls. In spite of their breadth, which is a normal characteristic of mature valleys, the enclosing walls, especially in the lower portions, are oftentimes exceedingly steep and even precipitous, a characteristic of young, not of mature, stream valleys. Thus the same valley has the characteristics of two stages of development, the breadth of maturity and the steep-sidedness of youth.

It is evident that such conditions as those which characterize so many of the valleys of the Inside Passage can not be due to normal conditions of stream valley development. The discrepancies and anomalies are altogether too numerous and striking for such an explanation.

FIG. 7. THE ROCK LIP OF A HANGING VALLEY JUST WEST OF THE NUNATAK IN NUNATAK FIORD. There is a vertical difference of 700 feet between the camera site and the lip of the valley. Photographs 9 and 10 were taken from this lip. Photograph by O. von Engeln.

If this is true of the origin of the valley forms, it follows that the present outline of the intricate maze of channels on this coast cannot be explained as a result of the drowning of normal stream-made valleys, as has been so universally believed to be the case.

It is now quite generally admitted that some of the features which characterize the 'Reaches' of the Inside Passage do not admit of explanation as a result of normal stream work. The feature that has been most uniformly admitted to be abnormal is that of discordance of tributary and main valleys. The explanation of this hanging valley condition as a result of glacial erosion, which this paper is supporting, is not, however, so uniformly accepted; the chief objection of those who have not yet accepted it being their belief that glaciers are incompetent to perform such great work as would be required if hanging valleys are explained in this way. In consequence of this inability to accept the conclusion that glaciers are powerful agents of erosion, a number of alternate hypotheses have been suggested, of which the following are some of the most prominent.

One of these special explanations is based upon the conception that glaciers act to *protect* rather than to erode. This explanation assumes that glaciers occupied and protected the tributary valleys while the main valleys were free from ice, and that, while this condition lasted, the main valleys were so deepened that, when the ice finally melted from the protected tributary valleys, they were hanging well above the over-deepened main troughs. When it is considered that thousands of hanging valleys are already known, and that in each case it was necessary for a small glacier to linger with its terminus at the very lip

FIG. 8. LOOKING INTO HANGING VALLEY (FIG. 7) FROM ROCK LIP AT ELEVATION OF 700 FEET. The stream flows in a small gorge at the right. The elevation in the middle background of the valley is the moraine-covered terminus of a dwindling glacier. The valley floor is all rock, and rock extends continuously across its mouth. Photograph by O. von Engeln.

of the hanging valley throughout the long period of time required to deepen the main channel, this explanation seems almost too absurd to consider. It furthermore fails to account for the aligned spurs, and, above all, for the great breadth and U-shape of the main troughs. While one might admit this as a possible cause for individual cases, it fails utterly as a general explanation.

A second hypothesis proposed, is that glacial erosion is lateral rather than vertical, and that the hanging valleys are due to the wearing back of the tributary mouths so that they are left hanging. That

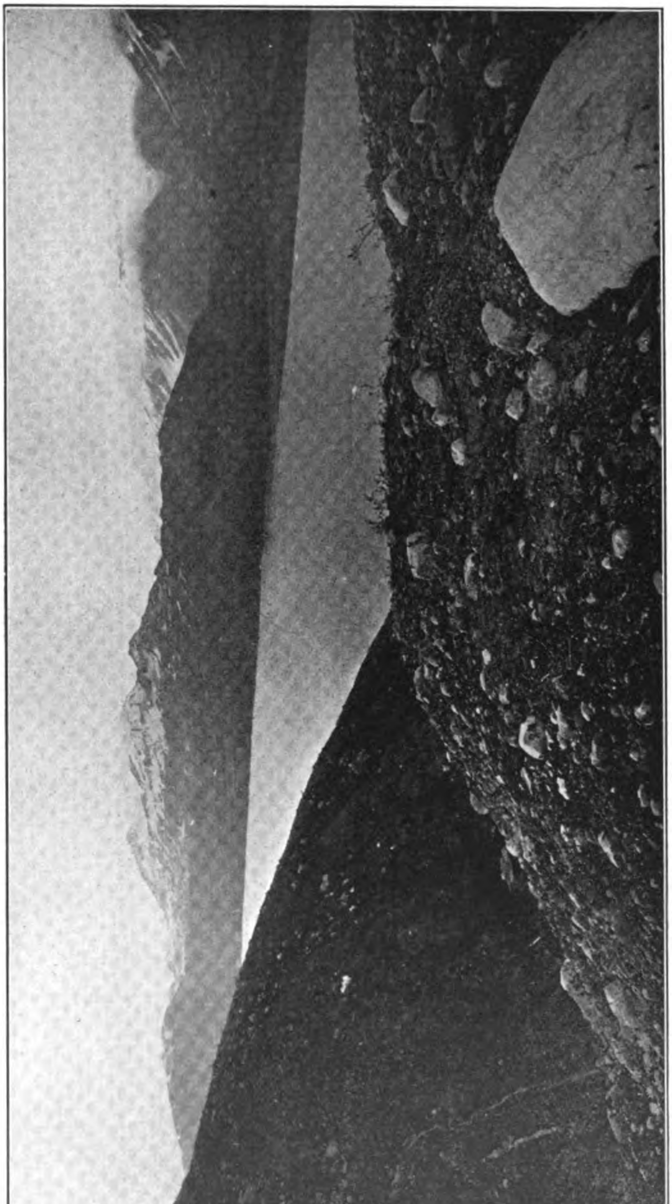

FIG. 9. FROM SAME SITE AS FIG. 8, LOOKING OUT INTO THE MAIN TROUGH OF NUNATAK FIORD TO WHICH THE VALLEY (FIGS. 7 AND 8) IS TRIBUTARY. Gorge cut in rock lip on left, bottom being just out of sight. Walls of gorge is rock, like rest of lip. Elevation 700 feet; depth of fiord unknown; but large icebergs float freely in it. Photograph by O. von Engeln.

there is marked lateral erosion is generally admitted by all believers in glacial erosion; but that this is the dominant form of glacial erosion would require for its acceptance much better evidence than has been presented. It may fairly be asked, if there is such pronounced lateral erosion, why should there not also be vertical erosion of equal or greater amount? Even if excessive lateral erosion should be granted as a possibility, of which there is no proof, it alone would fail to account for all the conditions observed. It would fail to explain why remnants of valley spurs are left side by side with pronounced hanging valleys; for in such cases the spurs should certainly be rubbed completely away. But, even more fatal than this is the fact that if the grade of the hanging valley is projected out into the main valley, it will, in a vast number of cases, fall far short of meeting the main valley at grade. Consequently, if glacial erosion is admitted at all, the element of vertical erosion must be granted as a prominent part of the process.

A third explanation proposed for the hanging-valley condition is that of capture and diversion of tributary streams. No one would deny that the diversion of a stream by capture might leave it hanging above the valley to which it was originally tributary. But to attempt to apply such an explanation to the multitude of known cases of hanging valleys would not be so generally accepted. It would require a marvelous development of stream capture in special localities and, strangely enough, almost entirely in regions of former glaciation. Before this hypothesis could be seriously considered as a general explanation of hanging valleys, it would be necessary to account for the fact that this process has operated so extensively in glaciated regions, whereas it so rarely operates in unglaciated countries. But even if this explanation were otherwise probable for hanging valleys, it still leaves unexplained the associated phenomena of aligned spurs, steepened lower slopes and general U-shape of the main troughs.

A fourth hypothesis proposed is that of rejuvenation. By this it is assumed that the main and lateral valleys had an accordance of grade during an earlier cycle of development, but that recent uplift, or other cause, gave to the streams a new power of cutting, making them young again, or rejuvenating them. As a result of this there was rapid cutting, the main streams working much faster than the laterals and leaving them hanging. This explanation is totally inadequate for the Alaskan conditions. It fails to account for the truncated spurs; it gives no explanation of the difference in level at which the laterals are hanging; and, moreover, even if it operated, it could not possibly produce the other results observed. Such rejuvenation would not develop a broad main valley, but a narrow gorge. But, even if we were to admit, which physiographers would not, that such deepening and broadening of the main valley would be possible without corresponding deepening at the mouths of the laterals, it is inconceivable that, during all the time required for the deepening and broadening of the main trough, the lateral stream was scarcely able to even scratch the lip of the hanging valley (Fig. 4). This point may be illustrated by a specific case, taken not from the Inside Passage, but from Nunatak Fiord, a branch of the Yakutat Bay Inlet which lies about midway between Sitka and Controller Bay just southeast of Mount St. Elias.

This fiord has been so recently occupied by ice that vegetation, excepting scattered annual plants, has not yet been able to take hold on the soil. The Nunatak Glacier (Fig. 14) has receded up this fiord more than a mile in ten years. Unquestionably there has been powerful glacial erosion here, for the walls of the fiord are smoothed and grooved by glacial grinding, and there are no valley spurs left. Several of the valleys tributary to the fiord are hanging high above it (Figs. 6

FIG. 10. LOOKING ACROSS THE MOUTH OF DISENCHANTMENT BAY, RUSSELL VALLEY (FIG. 11) ON LEFT. This valley is hanging at about sea level. A small valley to the right of this hangs fully 1,000 feet above sea level. A somewhat larger valley on the extreme right of the picture is hanging at a level intermediate between these two. To account for such discordance by faulting would demand very complex block faulting. But the rock walls of the fiord are plainly exposed and there is no evidence of it. Photograph by O. von Engeln.

and 7), and in all the larger of these small glaciers are still present. The entire absence of forest exposes the conditions here far more clearly than is the case along the forest-clothed Inside Passage.

Viewed from the fiord, the hanging valley selected for this illustration is plainly seen to be a broad, U-shaped trough heading well back in the mountains and with a small glacier at its head. The wide open mouth of this broad valley is truncated by the straight, steep rock wall of Nunatak Fiord and left perched high above even its water surface. This valley wall extends completely across the mouth of the hanging valley, forming a rock lip seven hundred feet high (Fig. 7). Climbing to the crest of this lip, one is able to look up the hanging valley to its mountain-walled head (Fig 8). It is found to be a broad, U-shaped valley with a flat floor and moderate grade.

The ice-born stream which flows along the bottom of this valley has cut only a shallow trench in the rock floor, through which it flows with moderate grade until the lip of the hanging valley is reached, when its grade abruptly increases and it tumbles down the main valley wall, as a succession of waterfalls, in the bottom of a gorge so shallow that the entire series of cascades, from the crest of the lip to its bottom, is plainly visible from the fiord. The stream has *begun* to lower its grade to harmonize with the main valley; but it has not had time yet to carry the process very far. That there is no possibility of the presence of a drift-filled valley of earlier date is proved by the fact that bed rock outcrops across the entire lip.

On any assumption of stream rejuvenation, it is utterly incredible that all the time required to deepen the main trough of Nunatak Fiord, and to broaden it into the form of maturity which it possesses (Figs. 9 and 14), should have been too short to have permitted the stream in the hanging valley to cut a more profound gorge, on such a steep slope, and to attain a better approximation to that accordance of grades toward which all tributaries tend in their relation to the main streams. Wherever one critically examines a hanging valley in its relation to the main trough, the same conclusion is necessitated.

A fifth explanation that has been proposed is faulting. It is of course admitted that a block fault, by dropping down the bottom of a main valley, would leave the tributary valleys hanging. Although admitted as a possibility for individual cases, the application of such an explanation to Alaskan conditions in general, fails utterly to account for the facts. It would not explain the truncated spurs on both sides, nor the U-shape of the main and lateral valleys. Furthermore, without the introduction of complicated secondary faulting, it would not account for the difference in level at which the valleys hang above the main trough to which they are tributary (Fig. 10). Another fact which ordinary block faulting would fail to explain is the frequent presence of a condition of double hanging valleys,—a lateral hanging above the main valley, and a tributary of this lateral hanging above it.

Such a condition of double hanging valleys may be illustrated by the case of Russell Valley (Fig. 10) which enters the lower end of Disenchantment Bay, a part of the Yakutat Bay inlet. This valley has a moderate slope and a remarkably well-developed U-shape (Fig. 11). Where it joins the fiord it has built a gravel delta, so that there the actual rock bottom is not visible; but about a mile back from the fiord, bed rock occurs in the valley bottom near its center. Extending

FIG. 11. PHOTOGRAPH OF RUSSELL VALLEY WITH LONG FOCUS LENS FROM WEST SIDE OF DISENCHANTMENT BAY. Mouth of valley about three miles distant; length of valley up to glacier (where the snow line ends) about five miles. Note U-shape, steep, smoothed walls, absence of spurs, and flat floor. The hanging valley shown in Fig. 12 is the first upland valley on the left. Photograph by O. von Engeln.

the grade of this valley out into the main trough of Disenchantment Bay, where the nearest soundings show a depth of from 600 to 1,000 feet, the profile falls far short of reaching the bed of the bay. It is assumed, therefore, to be a hanging valley with the lip at or just below the surface of the fiord water. If we grant that this particular hanging valley may be due to faulting, which can not be disproved, we are still left with the necessity of assuming block faulting along the axis of the Russell Valley to account for the hanging condition of its own tributaries whose lips lie fully a thousand feet above the Russell Valley bottom (Fig. 12). In some cases even a third series of laterals have been seen hanging above a tributary, which itself hangs above another, which is hanging above a main trough.

To propose faulting as an explanation for such a complex system of hanging valleys does not seem rational without definite evidence of the faulting, and without some explanation of why the results of such recent faulting are so common in glaciated regions and so rare in unglaciated areas. Moreover, in some of the cases mentioned, for example, the Russell Valley itself, if there had been such faulting, it would be easily detected in the sedimentary rocks which form the walls of the valley. Since a search for evidence of recent faulting in this valley failed to find it, I feel warranted in asserting that there has been no such faulting as the theory demands. A glance at the photographs (Figs. 10 and 11) is sufficient to show that the form of this valley could not be accounted for on the basis of block faulting. Its flaring, curving, U-shaped sides are not the forms characteristic of cliffs due to faulting. Should it be stated that block faulting occurred at a date sufficiently remote to permit the weathering back of the valley walls to the present curve, it is sufficient to answer that in all the time required for this, the lateral streams must of necessity have trenched the bottoms of the hanging valleys and reduced them to an accordant grade with the Russell Valley stream. As Fig. 12 clearly shows, this is far from being the case.

From the above statement of hypotheses it will be seen that it is generally admitted that hanging valleys are a peculiar phenomenon calling for special explanation. It is also true that this phenomenon is practically confined to regions of former glaciation. Together with the U-shaped valley, truncated spurs, and steepened main valley slopes, the condition of hanging valleys is reported not only from a wide area in Alaska and British Columbia, but in such other regions of former glaciation as the Sierra Nevada, the Rocky Mountains, the Finger Lake Valleys of central New York, the coast of Norway, the Alps, the Himalayas and New Zealand. While exceptional instances of hanging valleys, which are readily explained in other ways, have been reported from unglaciated regions, these are so few and scattered, and

FIG. 12. HANGING VALLEY TRIBUTARY TO RUSSELL VALLEY (FIG. 11). The first tributary from the mouth on the north side. The lip of this valley lies about 1,000 feet above the main valley floor, and the stream flows over it on the very surface of the rock, forming a gorge, below which it crosses moraine. A small glacier lies at the head of this hanging valley. Photograph by Lawrence Martin.

so unlike their abundant and striking development in glaciated regions, that they are hardly to be considered as bearing upon the problem.

The facts discovered in reading the literature and in field investigation, point to glacial erosion as the cause of the hanging valleys and associated phenomena, while no facts are found that are vitally opposed to it. Of no other hypothesis proposed may the same be said; on the contrary, all other explanations are open to fatal objections. The great majority of students of glacial action are now in accord with the belief in profound glacial erosion in favorable situations. Even those opposed to the explanation by glacial erosion admit that the forms under discussion are what would be *expected* if it were possible for glaciers to perform such great erosive work.

The few who are opposed to this explanation have been able to offer no better argument against it than their failure to believe in the ability of ice to do erosive work in great amount. Some of this opposition is based upon observations at the margins of small glaciers. But all such observations have little value; for, as has been well stated by another, if an observer could have been where ice was really capable of profoundly eroding, he would not have been able to come back and talk about it. The weak, retreating margin of a small valley glacier gives no better basis for understanding profound glacial erosion than a small meadow brook gives for a conception of the mode of formation of a Colorado Canyon. The objections to ice as an agent of profound erosion remind one very much of the objections which, in the early days, were urged against water as an agent of erosion. In this connection reference may be made to a short note, signed H. G., on page 249 of the *National Geographic Magazine,* Vol. 16, 1905. This little squib, which we may fairly safely ascribe to Henry Gannett, although written in a humorous and somewhat sarcastic vein, is really a noteworthy contribution to the discussion on glacial erosion. In it, as a sort of reply to a recent arraignment of glacial erosion, he applies to the now accepted belief in river erosion some of the same class of arguments as those which have been urged against glacial erosion, and with telling effect.

Since the establishment of the theory of profound glacial erosion is the work of the last fifteen years, and since the full force of the evidence has only recently been accepted by some of our leading physiographers, it is natural that as yet there should not be universal acceptance of so new an idea, carrying with it such tremendous consequences. But the fact that some workers have not yet accepted the doctrine does not necessarily constitute a strong argument against it, and certainly not enough to counterbalance the overwhelming evidence in its favor. When a large number of people are involved, ultraconservatism is always to be expected among some of them. There are, for example, even at the present day, some highly intelligent men who are writing

FIG. 13. THE NORTH WALL OF HIDDEN GLACIER VALLEY, A TRIBUTARY TO THE YAKUTAT BAY INLET, THE GLACIER TERMINUS SHOWING IN THE MIDGROUND. Note the smoothed, striated lower walls due to glacial erosion as contrasted with the irregular topography of the higher slopes due to ordinary weathering and stream erosion. A hanging valley enters at about the level between these two classes of slopes about a third of the way from the right margin above the glacier. Photograph by R. S. Tarr.

polemics in opposition to the belief in former continental glaciation, which almost every one now considers definitely established, though after a hard fight.

It does not seem necessary at the present time to undertake to show *how* the glaciers did this, nor to prove that they *could* do it when the evidence is so clear that they actually *did* do it. Suffice it to say, that if glaciers smooth, scratch and pluck the rocks over which they pass, as every one knows they do (Fig. 13), it requires only a sufficiently long continuation of this action to lower valleys to any extent up to the time when they cease to further smooth, scratch and pluck. A century ago it seemed to many observers that at the slow observed rate of recession of Niagara Falls it was impossible to explain

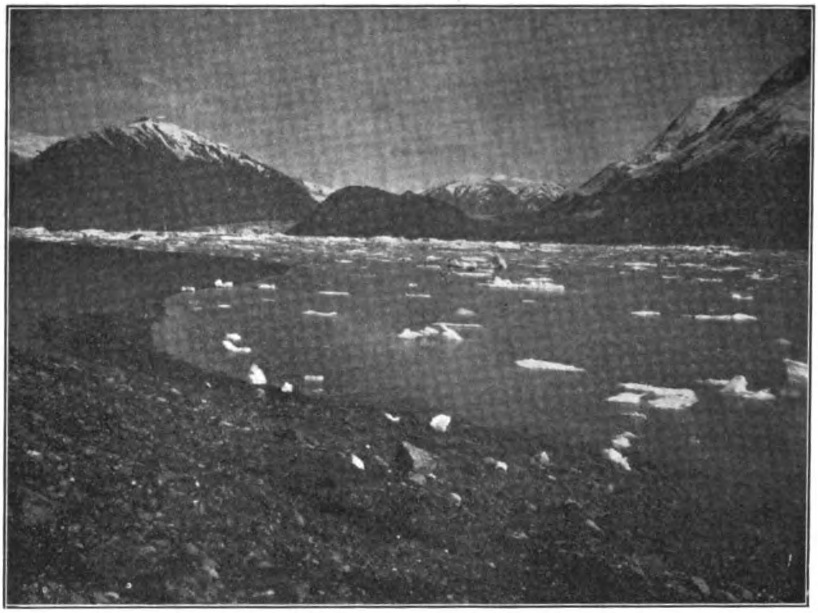

FIG. 14. LOOKING UP (EAST) NUNATAK FIORD. The rock knoll, or Nunatak, in the middle of the picture, 1,400 feet high, splits the Nunatak glacier. one arm, on the left, descending to the sea through the broader valley, the other occupying a smaller U-shaped valley on the right side of the Nunatak. but not upon reaching the sea. When first seen by Prof. Russell in 1891 these two arms nearly enclosed the Nunatak. The site of the hanging (Fig. 7) valley is on the right side of the picture. Photograph by Lawrence Martin.

the seven miles of gorge as a result of this process. No one now doubts this explanation of the Niagara gorge; and it is not doubted that the Colorado Canyon has been formed by slow sawing into the strata, like that which the river is now engaged in, but continued through a long period of time. An application of the same principle—a slow rate of erosion working for a long period of time—is all that is necessary to understand profound glacial erosion, once it is granted that glaciers do scour their beds at all, as every one admits, and that there is plenty of time available, as is well known to be the case.

Accepting ice erosion as a doctrine now established, as it seems to me we must, we will briefly examine some of the consequences of such erosion. Hanging valleys, U-shaped valleys, aligned spurs, and steepened valley slopes are among the more prominent of these consequences. From their existence we must of necessity infer enormous vertical as well as lateral erosion, such erosion occurring in places where actively moving streams of ice were concentrated in valleys along relatively narrow lines. Along the Inside Passage, and in Yakutat Bay, the two sections immediately under consideration in this paper, the amount of erosion which must be deduced from the evidence is in places not less than two thousand feet vertically; and erosion of this magnitude has occurred along hundreds of miles of fiords.

In discussions of the significance of hanging valleys, it has been rather common to speak as if the main valleys were eroded while the tributaries were left undeepened. This has been done here, as doubtless in other writings, in order not to introduce an unnecessary complexity into the discussion. It would, however, be entirely erroneous to suppose that the lateral valleys were not eroded also. It requires only an examination of the photographs accompanying this paper to see that the normal cross-section of the hanging tributary valleys has the same curve as that of the main valleys; that is, the curve which glacial erosion produces.

From the statement just made, it follows that the level at which a lateral valley now hangs above the main trough is not to be taken as the full measure of vertical erosion along the main valley. That this is true is indicated by the fact that of several valleys tributary to a main trough, no two usually hang at exactly the same level. There may be, and in many cases are, wide differences in the hanging levels of neighboring valleys (Fig. 10); some being perched far up on the mountain side, others so far lowered that the sea water enters and drowns their mouths (compare Figs. 2 and 5), which, however, are still hanging above the bottom of the fiord. Such differences in the hanging level are, in the main, a measure of the difference in amount of erosive work performed by glaciers in the several hanging laterals.

In general, those valleys occupied by the largest glaciers have been lowered most; and it may be stated as a law that, other conditions being equal, the height of a hanging valley above the bottom of the main trough varies inversely with the size of the glacier. The operation of this law is, of course, modified by the influence of varying rock texture, slope and other causes which tend to modify the rate of ice erosion. We are not yet in full enough possession of the facts relating to the process of glacial erosion to warrant an attempt at a full statement of the nature and result of the various influences which tend to modify the rate of erosion. There can be no question, however, that the nature of the valley rock is of profound importance, some weak rocks being eroded with relative rapidity by small glaciers, other rocks resisting the erosion of even large, powerful glaciers. Two causes, the size of the glacier and the nature of the enclosing rock, are, in all probability, of most importance in the modification of the height of valleys left hanging by more rapid erosion along the main trough.

An argument which has been advanced against the power of glaciers to erode, is the fact that rock islands sometimes rise from the floor of valleys through which powerful glaciers have passed. It has been claimed that such protuberances should have been erased if the glaciers were really eroding greatly. When the operation of glaciers as agents of erosion is truly understood, however, this argument seems to favor rather than to oppose glacial erosion. It is not to be supposed that glaciers would erode everywhere at the same rate. There is naturally a variation in the rate of erosion of a valley bottom dependent upon at least two important influences—nature of rock and rapidity of ice currents—both of which are liable to vary in any valley and thus necessarily give rise to irregularities in the ice-eroded valley bottom. Once an obstacle arose in the path of a powerfully moving glacier, it would have the tendency to split the ice current around itself, much as a sand bar spilts the current of a river. By interfering with the ice current in line with the obstacle, and by causing a concentration of movement on either side of it, the size of the obstacle would naturally increase. Rock knolls, islands and nunataks (Fig. 14) are such characteristic features in glacially eroded valleys that, when the full significance of glacial erosion is understood, I believe they will be found to constitute one of the distinctive evidences of glacial erosion, to be classed with hanging valleys, truncated spurs, steepened slopes and U-shaped profiles.

In discussions on glacial erosion much attention has been paid to rock basins,—basins with rock rims in the bottoms of glaciated velleys, and oftentimes holding lakes. Such basins also occur on the fiord floors of the Inside Passage. Irregularities in erosion, due to differences in rock resistance and in ice currents, readily account for these. As Andrews has shown in his remarkable papers on glacial erosion in the New Zealand fiords, one important cause for such basins, and other forms of vigorous erosion, is the convergence of ice currents in a valley of smaller cross section, causing acceleration of motion. Rock basins must be added to the land forms resulting from and hence indicative of profound glacial erosion.

Another feature at first apparently opposing glacial erosion is that hanging valleys, truncated spurs, and steepened slopes are at times well developed on one side of a main trough and either absent or poorly developed on the other. This, however, seems a perfectly normal result of ice erosion, for, as in a river, the current naturally at time impinges upon one side with greater force than on the other, as, for example, when by the entrance of a tributary the ice current is pushed against the opposite side of the valley.

A prominent feature in regions of former glaciation, both of continental glaciers and mountain-valley glaciers, is the presence of *through valleys,* that is, valleys in which there is now no pronounced divide. Such valleys abound in the Finger Lake region of central New York, and they are common also in Alaska, and, as Penck has shown, in the Alps. The evidence points to the conclusion that many of these through valleys owe their characteristics to the passage of ice across divides, and the consequent lowering of the divides by glacial erosion. In some places in Alaska, as in the Yakutat Bay region, the ice is still pouring across such divides; in other cases, owing to the shrunken state of present-day glaciers, the through valleys are now occupied by glaciers which flow both ways from a low, flat divide area across which, at a higher stage of the ice, through glaciers once passed. So far as seen in the Yakutat Bay region, none of the through valleys are entirely free from ice; but in many cases the glaciers are so shrunken as to expose the valley form, which is distinctly that characteristic of glacial erosion. In central New York, where the work was performed by continental glaciers instead of valley tongues, and where the ice is entirely gone, the character of these through valleys is easily observed. They are often U-shaped, steep-sided, straight-walled, and possess hanging valleys.

The acceptance of the conclusion that glaciers have been powerful agents of erosion, and doubtless still are where now in active operation, seems a necessary result of a candid consideration of the evidence. Once this conclusion is reached, a number of remarkable phenomena, otherwise not satisfactorily explained, find ready explanation. The belief in glacial erosion carries with it stupendous consequences, for it assigns to glacial action some of the most striking topographical features of regions formerly occupied by actively moving ice. Nowhere is the evidence clearer, or the results more striking, than along the Inside Passage to Alaska, and in the fiords northwest of this, such as Yakutat Bay. For those who still doubt the effectiveness of ice erosion, a trip through these fiords is strongly recommended instead of a study of the weak termini of small, dwindling Alpine glaciers.

THE RELATION OF SCHOOL ORGANIZATION TO INSTRUCTION[1]

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IN the text of an ancient story we are told that man was made out of the dust of the earth, and according to one version, at least, he was then leaned up against the fence to dry. Afterwards the breath of life was breathed into his nostrils and he became a living soul. This venerable myth, accepted in its substance as truth by a part of the human race for centuries, naturally lent its form to educational theory, and thus profoundly influenced the methods employed in training the young. From earliest times down to a generation ago education was a breathing-in process that simply continued and expanded the original act of creation. Then there arose a new conception concerning the making of a man and educational theory is slowly changing its form. Responding to influences from without, life is an unfolding process from within—this is the conception that is now shaping our methods of instruction.

The most interesting of all subjects of study is the evolution of evolution. That the development and maintenance of the organism depend upon its concessions to environment is a fact that has been recognized, in a general way, from the dawn of the evolutionary idea. The formal statement of the theory of evolution was long anticipated by the practical sense of the world in its knowledge of the dependence of the physical organism upon its material surroundings. But almost half a century has past since that doctrine was stated and even now we but dimly see its profound bearing upon the relation of the spiritual life to spiritual conditions. And the extreme newness of a certain phase of this higher aspect of evolution is evidenced by this meeting itself, which is perhaps the first ever called for the distinct purpose of considering the development of the social nature of the human being under the stimulus of social conditions.

The particular agency in social development that it is proposed to consider here is the school. It is not intended to deny that there are other agencies that have a similar purpose; it is the intention, merely, to maintain the thesis that within the range of its possibilities the school should be organized so that it may operate as a social institu-

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tion; and it will be the aim, also, to point out some of the most important changes needed in present school organization that the desired end may be attained.

The chief obstacle at present in the way of socializing the schools is found in their forms of organization. The machinery of the average school is an invention for the purpose of holding a pupil down while we educate him by the breathing-in process. A social institution is an organism; whereas, the school is formed essentially on a plan designed for dealing with a sum of particulars. It is treated as a body having merely the agglutinant characteristics of an aggregation. Few people realize that the transformation of a school of the average type into a social body means more than a change of name; in fact, however, it really means a revolution.

Regardless of outward forms and of protestations to the contrary, the real end of the school has been and still is the individual for himself and not the group. The school desk nailed to the floor circumscribes the space for the individual. The school grade represents an endeavor to get pupils together who are so near alike that they may be treated as an individual. The cry for extremely small classes, the exclusiveness of the small private school, the employment of tutors, all stand for efforts made toward the education of the individual for himself practically in a state of isolation. The dead and persistent drill upon the three R's backed up by the birch, by marks, by bribes, by promises of promotion, by threats and by cajolery has but a feeble socializing power. It is on the contrary essentially individualistic in the unwholesome rivalry which it always promotes.

If any one doubts the barrenness of the social life in our schools let him read as I have done in this the past few days the reminiscent records of students now in the university in which they narrate their experiences in the elementary schools. They tell of a dreary round of lesson learning with a little variation here and there as to the stimuli used, all of which were classed as either personal rewards or personal punishments. It was all summed up admirably by one student who said: "We always had text-books, and definite lessons were learned each day and recited, as it seems now, to the teacher because we invariably looked at the teacher while reciting and tried to see some mark of approval on her face." In the entire series of papers there is not a single instance noted when there was any attempt made to establish relations of helpfulness among the pupils themselves. There is, however, considerable mention of various means employed by the teacher to keep the pupils in a state of isolation from each other. As a matter of fact some of the most elaborate and artistically stupid parts of the school machinery have been especially devised for the purpose of keeping pupils from mutual assistance; whereas, the thing above all else demanded in society at large is that its members shall help each other to the utmost. The only places where mutual helpfulness is not recognized as being in every way worthy is in school and in prison; in this particular the teacher behind the desk and the guard mounted on the walls have something in common. It is most unfortunate that this tendency toward mutual assistance is treated as though it were an iniquity—as an especial brand of original sin; while, in fact, it is the latest dawning and most lovable, civilizing trait in human character.

The proposition to transform the school into a well-organized social institution is not merely a matter of abstract theory or pure science. It is a definite expression of a movement to make the schools in common with other agencies a positive force in bettering the conditions of life.

This proposition rests upon the foundation stone in human character that up to date has been rejected by the educational builders—namely, the natural tendency of children toward helpfulness. The spirit of consideration and helpfulness is what we most need in human life and the schools must cherish it in the children and train directly for it. The kindergarten, here as ever, is the best type of what we want in school life clear through the university. Go into any good kindergarten and note how gladly the children participate in the many opportunities for cooperation in living their simple and beautiful life. Go then into the upper grades, and into the high school, and into the university and observe how one by one those opportunities for participation in the upbuilding of the public weal have been withdrawn and mark the degenerative effect of this loss of opportunity upon the social qualities of the pupils!

There are in this country many universities that number from 1,000 to 5,000 students each year. These young people represent a virile period of human life, when hope is young, aspirations are keen and the will is dominant. But when taken in their totality, in their power or in their desire to organize as an influence upon any phase whatever of human affairs, they are as innocuous and as ineffective as a flock of sheep on a sunny hillside in April. There is not a university president, nor a professor, nor a university department of sociology, to my knowledge, that has ever yet organized the splendid native force of a great student body towards any public end that is worth the attention of an intelligent man. Nor does the student body itself show any such disposition to organize. The highest watermark that has yet been touched in fusing together the community forces in the great universities is represented by the college yell for the foot-ball team! No other state institution could so completely withdraw these thousands of young people from a consideration of the interests of public welfare.

Even in darkest Russia, with every influence against them, with no public school system, where blackest ignorance is the rule with the people, the student bodies in the universities represent perhaps the most powerful hostile influences with which despotism must contend.

This shows the power of student life when it organizes itself under the whip of a great purpose, and it mercilessly exposes the enormous moral loss to society and the delinquencies of an educational theory which permits any diversion of these forces of youth from the work of upbuilding the social and national life.

The economic vandalism of our time can be charged to no one person or thing; but responsibility for it may be laid directly at the door of a school system which permits this social deterioration to begin in the earliest years and thence onward to increase in a steady ratio throughout the higher institutions of learning.

All schools, however, have always had some social life of a more or less organized character. In the plays and games outside of school hours; in the stolen whispers of the study and recitation periods; in the clandestine schemes laid for the discomfiture of the teacher; in the literary societies, and in many other ways, through the exercise of their social instincts, the pupils have managed to make their school days tolerable for themselves and, to a like extent, often intolerable for the teacher. But these aspects of school life have been, and still are, considered as diversions, as incidents and somewhat as detriments to what is called, in school parlance, the 'regular work.' It is largely due to this fact that in most schools the socializing process as yet remains inchoate.

There is a misconception, almost universal, concerning the organizing center of the school as a social body. Recognizing that in the past the chief organizing influence has come through the exercise of the play instinct, the unguarded inference is that it is now proposed to socialize the school through play alone; or, what comes to the same thing, by the introduction of work which shall be turned into play! It is through this perverted idea that the New Education stands charged with triviality in its methods and with a disregard for that robust discipline which comes through sturdy and purposeful work. Nothing could be farther from the truth. Students in the philosophy of education are slowly coming to understand that the spelling-book, as such; that the endless repetitions which usually accompany 'formal number'; that the struggle with words merely for the sake of a vocabulary in reading; that the wrestle with technical grammar as an introduction to the study of language—that all these and other subjects of like kind, as they generally appear in the schools, are essentially unsocial in their influence. Such students believe that herein lies a great obstacle to that reform which seeks to socialize the schools. If, however, this so-called work is to be removed from its present dominating position in the curriculum, it is as yet inconceivable to most people how there can be anything to take its place except play. It is only too true that in many schools where the old technical drills have been discarded, the teachers have been unable to find anything worthy to take their place, and there at once develops a tendency towards inferior social types of organization. These lower social units taking root readily in a school where many of the old arbitrary means of control have been abandoned, inevitably become immediately inimical to the broader interests of the school as a whole. In this condition of affairs we find that *raison d'être* for the fraternities and sororities in the high schools.

The prime necessity in the social organization of the school is that there shall be an abundance of those activities which are capable of yielding tangible results in worthy products having a common interest. The distinction usually drawn between the activity of play and the activity of work has neither meaning nor value in terms of growth. Both play and work may be good or bad, educative or otherwise; that depends alone upon the motive. The infallible test is found in the character of the output; it is a measure that anyone may apply with ease and directness when education is conceived to be a concern of the familiar things of life.

An educational activity with an organizing value is one which expresses itself through some helpful work. This is not a machine-made definition—it depends upon the nature of things. It is rooted in the fact that every child is a born worker and a lover of work. To work, to do things, to bring about results, useful and beautiful, is just as natural as it is for him to breathe the air. There are no lazy children, naturally. Catch them young and treat them right, and they are all workers and lovers of work. A lazy boy is merely either one who is sick, or one who does not like to do something which a 'grown-up' thinks he should do; his indisposition, if not a matter for the physician, should be placed to his credit. A big boy came to my office one day who was too lazy, the teacher said, to be allowed to remain in school. I asked him what he would like to do if he were left entirely free to choose, and he replied: 'I would quit school and go to work!' I thanked him—inwardly—for his criticism, over which I have since deeply pondered. Doubtless the 'work' which this boy would be able to pick up in the streets would be as little to his taste as were the tasks left behind in the school. For the average employer rarely considers the soul-life of the employed. He stands a good chance of falling into the hands of a man who wants to get more gold out of dry goods and groceries than nature has put into them and he tries, therefore, to make up the deficit out of the boy. So between the teachers who do not know enough and the business men who do not care enough the lazy boys are easily turned into the path of the transgressor. Laziness is the merciful invention of nature, whereby she holds them for a time at the parting of the ways, and enables them during this period of wavering to escape the stupidity of the schools, on the one hand, and the heart-breaking conditions of business on the other.

It was a bad day for education when it got itself placed over against work; when it made work a penalty for the stupid and a punishment for the perverse who would not allow education to be breathed into them—and education is just finding out its colossal blunder. Figures from the fourth grade up show that, when it is solely a question of school or work, it is work that wins the contest, hands down. Of the hosts that enter the primary grade, practically all the children of all the people, by far too small a per cent. finish the eighth year; of these a still lesser per cent. go to the high school, and beyond this there is scarcely more than a negligible minority. This absorption of child-life by the world's work all takes place in the face of modern educational theory, our advanced views of culture, our legal enactments, and the truant officer!

Any fair test applied to a school will show two things: first, that the pupils are capable of far more productive work than is now called for and, second, that they are anxious for more of it. This fall this question was put to about two hundred pupils from the sixth grade up: If the building were open to you after school, would you like to stay for extra work? What would you like to do and how much time would you use? In the replies received all but twelve or fifteen said they would like to stay from one half hour to two hours on from one to four days a week. The range of choice was practically all among the arts and crafts. Work in the wood shops was most popular, there being about sixty applicants for this, while work in metal, in clay, in textiles, bookbinding, printing, gymnastic dancing, photography and many others had a strong following.

Yet education is not wholly a matter of tasks. This is the pitfall that catches most of our critics who contrast the old with the new. If education were the result of tasks arbitrarily imposed; and if the old set tasks for the pupils that were difficult enough to hold them to the top notch of effort; and if the new levied only those that were so easy that the pupils became dawdlers, then the apostles of the present régime in school would have it their own way. But here is the difference that is world wide. The new, while rejecting the idea of imposing tasks arbitrarily, seeks to establish conditions which challenge the personal initiative. The old over-emphasizes attainment as a quantitative result: The new values attainment only as it represents a quality of mind that has acted through its own initiative. The old recognized as training and discipline the so-called voluntary attention which seemed to be mainly the ability to stare, ox-like, a disagreeable, uninteresting or unintelligible thing out of countenance. The new believes in the training and discipline that come from the pupil's effort to follow up from premise to conclusion, something which mightily interests him because of its worthy purpose. The old found satisfaction in a state of mind that was quietly receptive; the new sees hope in the turbulence of inquiry; and all of these are irreconcilable differences in kind.

When the work of the children springs from their own initiative, it will become essentially creative and not imitative. The theory that the educational process is imitative and not creative especially in the earlier and formative years of childhood is as old as psychology itself and in practise the proposition stands almost unchallenged. The average curriculum is formed on the idea that the pupils are imitators, the followers of directions, and not creators and it is consequently imposed. The daily lessons in scope and character, the methods of the recitations, the modes of expression are all prescribed and all the activities of the school are reduced as nearly as possible to that monotonous routine known to the devotee of system as 'regular work' which offers no play for the creative intelligence in either thought or deed.

The constructive idea now being realized in various forms of handwork is the thin end of the wedge that is opening the way to reform. Anything which involves the hand immediately arouses the creative instincts. Much of this work is still of the illustrative type, merely reproductive or imitative and in the beginning it was all of that character. In wood, for example, the 'exercises' were all once manacled to a set of models that made no claim upon creative powers either through their use or beauty.

At present, nearly all subjects in the curriculum make some application of the constructive idea. The lessons of history are vivified by reproducing typical creations of other days. Science becomes somewhat more real by the performance of experiments set by book and teacher. Mathematics has been improved through its applications to prescribed construction. Something of both the technique and the spirit of art is acquired by reproducing the work of the masters. This all represents a distinct improvement upon the old régime of books and lectures, and such exercises will always form an organic and necessary part of an educational system.

But the high-water mark in school-teaching will be reached only when such work becomes secondary because it is supplementary and subsidiary. Only when the dominant note of the school is clearly creative does it lay direct hold upon the vital and continuous interests of the children and become essentially educative.

This is true regardless of subject-matter or material on the one hand, and age or sex on the other, and to this fact some curious schoolroom phenomena are due. Parents frequently marvel that the boys of all ages delight in cooking and textiles, while the girls are equally interested in woodwork and other forms of heavier manual training. The reason, however, is clear. It is not that there is anything inherent in either the dough, or the cloth, or the wood, or the iron, but rather because the work under all these heads is largely creative. It is because an aim is set up that is unique; it is somewhat new because it is personal—it is because the ages-old materials must be combined to fit new occasions that the interest is enlisted and the best original efforts, and consequently the highest educational results, are obtained.

Every creative activity will have its artistic aspect; for when the soul enters a creation, then and there art is born. Art-forms are now rarely creative. They do little more than tickle the sense with the pleasures of a fleeting hour—and they are worth all they cost for that! But when the lives of the children are properly enriched, music, painting, drawing, sculpture, and the rest will come forth as creations—the radiant allies of speech. In language growing fluent and supple, the pupils will learn to wreathe in descriptive, dramatic and poetic forms the subtlest creations of which the human mind is capable.

Creative work transforms the individual. Through it, alone, he grows and maintains a personality that makes him different from others. Through it, alone, his generation rises above all that have preceded. Imitation is a training in conformity. It holds the creative instincts in abeyance until at maturity it is the exceptional man or woman who is not hopelessly bound by the shackles of convention. If he would ever create, he must override the prejudices ground into him by the schools, and, even then, the daring freedom of childhood but rarely comes again. The gospel of conformity teaches that the best has been done—that naught remains for us but imitation. This, too, in face of the practical fact that the discoveries of to-day have sent to the scrap-heap the brilliant inventions of yesterday! The effect is not less marked in the realm of morals. Generally speaking, the ethical code of the school has been copied from that which once served the purpose of the generation that developed it, but it is far below what, under present conditions, the pupils can create for themselves.

The final test as to the value of any piece of educational work in the development of children of whatever intellectual capacity is determined by their appreciation of its worth in meeting a natural demand. Unless their energies are constantly directed toward filling a recognized want, the pupils put forth their efforts in vain, and the routine of the school becomes merely the rattle and grind of empty machinery. Upon one trait in his pupils the teacher may forever reckon: they will always respond to a need which they can really feel and understand. A study of our city parks showed how impossible it was for certain useful and beautiful birds to find suitable nesting-places in the trees and shrubs. Forthwith practically every pupil in the school volunteered to make boxes for the nests. Whether the smaller children could make an entire box or not mattered but little; the strength of their want through a real sense of the need, coupled with the little they could do, added cubits to their moral stature.

A practical difficulty in the way of teaching children to realize their motives in some useful end, is that to many people it looks too much like common work; there are parents, therefore, who strenuously object. They say their children can get that at home, and that the school should stand for something else—for culture! This is a curious fact, in view of the glorification that labor is now receiving at the hands of the people. However, the large storekeepers do say that this great revival of enthusiasm for labor has not as yet appreciably increased the demand for overalls and jumpers. No one has reported, so far, that the cuts of these elegant and useful trappings of toil are appearing in the latest fashion plates of our high-class tailors. From this it may be inferred that with most people the labor question has not yet gone beyond the stage of academic discussion. Hence the difficulty of getting the pupils actually to work either in school or at home. Last year the children wished to have blooming plants in their school-room windows. They thought to improve matters by substituting for the unsightly pots the more beautiful creations of their own hands which they could easily make in the clay-room. Immediately a parent wrote that if our pupils could find nothing better to do than to make jardinières to beautify the University of Chicago he would take his son from the school—and he did! The kind of school which this type of parent really wants is one where his boy can insensibly acquire curvature of the spine, a sallow complexion, spectacles, and—culture! We have trade and technical schools that give education for the sake of labor; we must now have schools that give us labor for the sake of education.

To sum up, therefore, the resources of the school which the teacher may utilize in the development of a social organism we have on the part of the pupils (1) a natural spirit of helpfulness; (2) an inborn love of work; (3) a desire to take the initiative; (4) an ambition for creative work; and (5) an alertness of mind toward public needs. Upon these foundation stones the social structure must be reared.

That these qualities of character may be normally developed, the curriculum must provide an abundance of suitable material; the class exercises must keep to the forefront matters of public interest and the entire organization must offer a maximum of freedom to the individual who thinks and works in the interest of the common welfare. Everyone recognizes these elements of character as being those which give us the highest type of citizenship in the community at large. It is interesting and pertinent to inquire why they do not give corresponding results in the school. People generally seem to understand that the school should reflect the interests of the community, but the traditions of the school are such that the instant an industry or an art is introduced into the schoolroom the tendency is to erect it at once into a 'subject of study.' This means to the average person that it must have its special teacher, its arbitrary place on the program, and in other ways take a definite setting in the curriculum. Now, there is a vast and an essential difference between this kind of so-called organization attempted by the school, and the actual organization which takes place in true community life. If, for example, under normal conditions, in the latter, a wagon is to be made, the various activities that contribute to that particular end are so correlated as to combine efficiency and economy. Everybody's efforts are directed to that result. There is just so much wood needed and no more. A premium is placed upon the endeavor to use as little as may be consistent with the character of the wagon desired. The same is true of the iron work—no more bolts or bands are made than are actually needed. So, also, it is with the paint; what the wood needs for its preservation and adornment is used, and nothing beyond. But bring these industries into school as 'handwork,' and we find only so many more 'subjects of study' that in some way must be juggled into an already overcrowded program; only so many more teachers that are to increase the wear and tear in already overwrought children. It is no longer a question of doing just as little as is needed, but as much as possible! It is as though the wagon-maker were to go ahead blindly and make a dozen wheels where only four can possibly be used; as though the blacksmith should forge a hundred pieces of iron where but twenty are needed; and as if the painter should demand forty hours for his work when five would be altogether adequate. We are in an incipient stage of development, where there is insufficient attention given to the relation between demand and supply. The work generally in any particular subject represents the strength and the personal push of the teachers, or the reverse. If by superior wit, or by greater cunning, or by sharpness of tooth or strength of claw the ambitious teacher is able to get a lion's share of the program, his particular subject may be correspondingly magnified, even to the detriment of all others.

If the school is to approximate still further the ideals of community life it is necessary that there should be a more flexible adjustment of the workers to each other and to the thing to be done. The grouping and distribution of the pupils should be based upon the nature of their work. The school grade as now generally constituted is a pure fiction in philosophy but it is a stubborn and unreasonable fact in practise. Under the domination of the grading system, the school reverses or ignores most of the principles that control people in practical affairs. Under its operation, it compels the teacher to lay the greater emphasis upon the similarities among pupils, and to ignore differences, and it places a premium upon uniformity. The more closely the school grade approaches its ideal, the more strictly must each pupil work for himself; while the closer we approximate the grouping required by the social ideal, the more earnestly must the individual strive for the whole.

The school grade aims at a certain dead level of uniformity in three things, namely, age, knowledge and skill. These rigid conditions have imposed the stamp of their own arbitrariness upon the selection of subject-matter and methods of instruction, and they render it impossible to realize the highest ideals of social and civic life in the school. The grading system was established long before child-study opened the eyes of teachers, and it represents the quantity idea in education as opposed to that of quality.

In school, not all of the teaching is done by the teacher; the younger children are constantly learning from the older. Experience shows that when pupils have the opportunity to organize themselves for work they form groups which in many instances utterly ignore the age limits set by the grade. The younger pupils gain in skill and knowledge, and the older have lessons in consideration for others and in responsibility that in a graded system must remain forever untaught.

It is equally undesirable to grade pupils on the basis of equality of knowledge. Outside of school such an aggregation of people would be considered a stupid company, with but little chance for improvement. It would distinctly improve the situation to bring together in some common enterprise pupils who differ widely in both knowledge and experience. This applies especially where the pupils are employed in doing rather than in talking. The less capable learn from those who know more, and the latter will learn to work from the strongest stimulus that can move anyone—the necessity of making knowledge immediately intelligible and available for others. The nearer the conventional grade is approximated, the less there is of such a motive; for a similarity of knowledge makes each one useless and uninteresting to every other.

The same argument applies against the requirements for a parity of skill. Every pupil has a certain skill of his own, and his work should so relate him to others that he may make the most of it. He need not be 'graded' with those having equal skill in the same direction. This point finds illustration in the building of a house. In this there may be six or eight different kinds of workmen employed. No two have quite the same skill, in no two is it required. Each one does what is needed and what he is best able to do. The group is so organized that the house-building progresses rapidly and well; but the organization bears no resemblance to that arbitrary aggregation known as a 'grade.'

The effect of the present grading system upon the treatment of subject-matter has been pernicious. It has led to endless attempts at cross-sectioning subjects, in order that certain portions may be trimmed down to fit the pigeon-holes of the grades. This is reflected in thousands of text-books, and there is scarcely a subject that has not been marred by the ill-advised analysis.

The evils of arbitrary grading are not less marked in their effects upon the teacher. The notion that each grade must have its method is most persistent at the two extremes—the kindergarten and the high school. Those entering a course of training for the kindergarten are loath to trouble themselves with what lies beyond; and the would-be high-school teacher is apt to regard a suggestion that he look into the nature of elementary instruction as a reflection upon his intelligence.

The influence of the grading system upon the pupil is necessarily bad. It retards his progress through the elementary school, and it fosters selfishness. In the wake of the grade, trail many evils that fret the children. Not the least of these are the marking system and formal examinations, which have done more to introduce and foster knavery during the impressionable years of childhood than all other agencies combined. Under such unphilosophic and arbitrary stimuli to action, it matters not how hard he may try, no pupil can grow up wholly honest or unselfish.

Grouping of pupils under the ideals of the new education rests upon a principle radically different from that which now prevails. Under the old ideals, the children must exert themselves to excel each other. Under the new, members of a group must exert themselves to help each other. In the former, the work is so planned that each must strive for the same thing—the very same bone; in the latter that—as in the building of the house—the best effort of each is a needed contribution to the welfare of all. Each, therefore, must encourage and support the other. It is the operation of this principle that at once divides the light from darkness, that lifts civilization out of barbarism, that filters righteousness from iniquity, and that will finally give us the ideal school. The problem of grading and grouping of pupils will be solved when the children are permitted to plan work for themselves that demands cooperation. It must be for an end that no one by himself can attain, that, in school as well as out, the principle may be established that no one can live unto himself alone. That is the supreme fact in democracy.

The reorganization of the schools on the basis of community life makes an imperative demand for a new type of trained teachers. Academic training has been amply provided for and it hereafter will be assumed. The past generation has done practically all that need be done to place within easy reach of every intelligent teacher whatever it is necessary to know concerning special methods. Within the same period the subjects of psychology and child-study have been thoroughly worked over, and the results have been fully and clearly presented. This part of the teacher's training, hereafter, will not become of lesser importance, but it will be more and more assumed as a preliminary to the newer training which the public is now demanding. The greatest need of the schools is teachers who have the power to reach the public mind. The power to teach the children will be taken for granted.

The new type of training will not be found in a further elaboration and intensification of book study and theoretical discussion; nor will it appear in a further development of specialization as that is now commonly understood. It will be based upon actual 'field work' carried on in the community at large. That is, the teachers in training must study the needs of a community as they manifest themselves in its daily life; they must, in fact, in some way become actual participants in that life. No other kind of training will ever equip prospective teachers to answer questions which the public is now asking. The school must go into the service of the community more directly, and the community must open itself up more freely to whatever service the school can render.

Up to the present time the training schools for teachers are all modeled upon the plan and after the ideals of the older educational institutions of an academic type, and these, in their turn, grew out of the cloister. The training schools for teachers, on the contrary, should be modeled rather upon the plan of the so-called social settlement, and the ideals of the teacher must become more nearly allied to those of the settlement worker. Every school should be so organized as to draw all the people together for the purposes of work, of study, and of recreation, as the public library now attracts people who wish to read. To this end, the studios, the workrooms, the laboratories, and the libraries of the schools should be open under the supervision of the teachers, as public libraries are under the librarians, to suit the convenience of the people. They should be open at least as many hours as the saloons. A training school for teachers that could place its prospective graduates for at least a year in such intimate relations with community life as the settlements afford would give them the best possible preparation for undertaking with the people the joint task of educating the children. This does not mean, of course, that such training can be acquired only in the reeking and congested districts of the cities. Every locality in city, village, and country, should offer some opportunity for the practical training of teachers in the science and art of working with people. The teacher should take a leader's part in the debate of every question that relates to human welfare. It is only by the most active participation in public affairs that he can keep himself in proper training for the task of teaching the people's children.

The coming era of education will be marked, not by its material resources, but by its teachers. Our school houses are good enough; now let there be trained teachers, then we shall have schools. Such teachers will be equipped, of course, with knowledge; but above all they will be trained in discernment—in the power to see and appreciate the fundamental things of human growth and in its output of character. They too must work with the children, not alone for them, and be creative; to create they too must be free. The present system that grinds and chafes at every move was developed under archaic ideals; it has become antiquated and in large measure useless. The organization of the schools must grow out of the professional necessities of the teachers, the greatest of which is that even the poorest shall be free to put the best of himself into his work. Under such conditions every teacher and every child will become a positive creative moral force in the upbuilding of the social structure.

IN SEARCH OF TRUTH[1]

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AT the January meeting of the Astral Club at Alcalde, Mr. Arthur Grimshaw, of Berkeley, the newly appointed science teacher of the Alcalde Union High School read a curious and interesting though revolutionary paper on the 'source of knowledge.' His title was 'What is Truth?' This paper was highly appreciated by the club as the example of the best results which can be attained on the material plane of thought. The author's failure to rise to the heights of astral conception was however painfully evident. It is plain that in the laboratories where his training was secured all esoteric sources of truth have been ignored. But as the Astral Club of Alcalde, though I say it who should not, is nothing if not open-minded, it shall be the duty of the secretary to transfer to this record the substance of this young man's views on the tests by which truth may be known.

Mr. Grimshaw began by a discussion of the significance of 'philosophic doubt' whereby men question the only things they know to be true, in the hope of proving the reality of things they know are not true. For if you can show that truth and falsehood are identical in the one case, it lends probability to the theory that falsehood is truth in other cases. On this general argument are founded many forms of modern philosophy and of ancient philosophy as well. Mr. Grimshaw said:

"What I mean to show is that all truth is truth so far as it goes. The things we know to be real are real and we are not deceived in believing in them. The proof of the reality of an object, the truth of a proposition lies in the fact that we can accept it and translate it into action, into life. If it were not true we could not act upon it. Acts based upon it would sooner or later put an end to existence.

"The real nature of an object before us may make little importance to us. It may be solid rock or empty vapor, if we choose to let it alone. But the moment we form relations with it its reality becomes a vital matter. If it is a rock or an apple, then rock or apple it is in all its relations. If we view the apple as something essentially different from what it is, there will be similar errors in our thought of other things. If we are deceived as to the rock we shall have unsound notions as to other things.

[1] Being further extracts from the Journal of the Astral Club of Alcalde.

"Poisons would seem as foods, foods as poisons; pleasures as sins, and sins as pleasures. The whole sanity and accuracy of life would be destroyed. For the security of action is conditioned by the exactness of our perceptions of the relations of external things and by the correctness of our reasoning in regard to these perceptions."

Mr. Grimshaw, falling back on the lore he had learned in school, said:

"In psychology the term *reality* is sometimes applied to a sense perception which is based on an outside influence acting then and there. In this sense the *reality* is not the external influence itself, but our direct or normal perception of it. Thus, the impression made by the sound of a gun would be a reality when the pressure of air waves reached the brain, though the explosion may have taken place some seconds before. This reality as it comes to the brain should bear a definite relation to its source. In other words it must give the mind such information that the actual occurrence may be correctly interpreted. On its correct interpretation the fitness of our response in action must be conditioned. The term 'common sense' is applied to the normal working of these brain processes. An external stimulus produces a reality. The reality is transmitted to the brain where it is considered in its proper relations. Afterwards an impulse to action passes along the motor nerves to the muscles, which are the servants of the brain.

"In simple matters, as those pertaining to the apple, the dictates of common sense are obvious enough. The feelings are not moved by an apple, and our recognition of its nature is clouded by no illusions. But there are many relations in life in which 'common sense' does not find the problem so easy. If we examine the actions of ourselves and of our fellows, we shall find that the 'common sense' of different men does not act in parallel ways, and what seems to one wise or natural becomes grotesque or absurd to another."

Mr. Grimshaw then gave a number of illustrations of thought or action in which the 'common sense' may be deceived:

"You are in a railway train which is waiting on a side-track. Another train comes in sight, its motion seems transferred to your own train, but in the opposite direction. This motion continues until the other train has passed. It ceases suddenly, when you can almost feel the jolt of its stopping. But from other observations you know that your train has not moved in all this time.

"This is a simple illusion, easily corrected by the mind before it passes over into action. Let us look at some others. The story is told of a merchant who, smacking his lips over a glass of brandy, said to his clerk: 'The world looks very different to the man who has taken a good drink of brandy in the morning.' 'Yes,' said the clerk, 'and he looks different to the world, too.' Now, which is right? Is the world different that it looks brighter? So it seems to the man's own 'common sense.' Or is the difference subjective only, in the man himself, who has lost his bearings to the outside world?

"The revered sage of Los Gatos, Brother Ambrose Bierce, tells the story of a man who visited a naturalist in San Francisco, and remained over night as a guest. The naturalist was fond of snakes and had several of them in the house. When the visitor retired at night he looked under the bed and found a great coiled serpent, who watched him with glittering eyes. These eyes made some strange impression on him, and in the morning the people of the house found their guest kneeling on the floor, dead, his open eyes still staring in horror at the thing under the bed. This thing was the stuffed skin of a kingsnake with two shoe-buttons for eyes. The 'common sense' of the man told him that the snake was charming him, and in the belief that he was charmed to a horrible death he must have perished. If he had not believed that snakes have the power to 'charm' and to kill, surely he would not have died.

"It is said that a ship once landed on a barren island in the Pacific Ocean. Its passengers brought with them the materials for a house, which they set up, to the surprise of the natives who had never seen a wooden house before. They put in it blankets and cooking utensils, and after a day or two they set up near the house on a solid foundation a long tube through which they gazed by turns at the sun. After watching the sun for a single day, they hastily returned to the ship, carrying the long tube and the blankets, but leaving the house and everything else of value on the island. The delighted natives took possession of the house and they hold it to this day. But they look in vain for the return of the foolish people who left it there.

"Men who have traveled in Mexico tell me that all along the coasts of Sinaloa, people are engaged in digging for buried treasures under the direction of men or women in San Francisco. These people have never been in Mexico, but they are said to have the power of seeing clearly objects not before them, in any part of the earth. There is a very old legend current which tells that a pirate ship, hard pressed by the Mexican soldiers, landed on the Cape of Camarron near Nazatlan, where the buccaneers hastily buried a vast treasure of silver, after which they all fled. A man is engaged to-day in boring a tunnel into solid granite and lava to find the treasures thus laid away. A woman, in a shabby Sacramento Street boarding house, claims to see in her trances the inner secrets of the mountains and directs all these operations. Our common sense or our experience may condemn the whole operation as ridiculous but the transit of Venus seemed equally absurd to the local critics who occupy its abandoned shelter.

"One man takes a forked rod of witch-hazel, and, going over a tract of land he feels the fork twist downward at a certain point. He digs there and finds a well of living water. If there is much water the rod turns more vigorously or even turns the other way. Another uses the same rod and finds coal, iron, gas or building stone—whatever he may seek. To do this he has only to attach to the branch of the rod a small fragment of that which he would seek. Thus a dime may be attached if one is seeking for silver, a five-dollar gold piece if one looks for gold. In California where there is no witch-hazel the mountain willow serves the purpose best, because there is water in its make up. But even the madrono or the azalea can be used in an emergency. A man once tried to bore for gas on a certain tract of land in southern Indiana. He engaged a soothsayer with a witch-hazel rod. But the wizard, finding the territory too large to be gone over in this way, makes a little rod, parlor size, and taking the map of Vanderburg county, goes over it with the instrument. The result was just as satisfactory. He chooses a point on the map, they bore the well in accordance with the rod's directions. Plenty of gas is found, which proves the accuracy of the method. As Lord Bacon once observed 'men mark when they hit, but never when they miss.' Still another man wishes to find the material of which a star is made. He takes a tube of metal with lenses and prisms of glass and turns it toward the star. Speedily, by means of lines and streaks on the prism he has his answer, and the composition of a vast sun, so far away that the light which left it in the days of Cæsar has never yet reached us, he describes with confidence. Then he turns his tube on the Pole Star and tells us that it is made of two stars, one a great sun which we can see, and the other a smaller sun which we have never seen and which we can never see. Is all this real? If the spectroscope tells the truth where it speaks in such bold fashion, may we not trust the witch-hazel, too, in its more modest claims?

"An astronomer traces the course of a far-off planet and finds that its orbit bends a little from a perfect ellipse. From this fact he concludes that another planet must be coming near it to attract it. He goes to work to determine the size of this other planet and the place in which it ought to be. When his calculation is finished the telescope is turned toward this place, and the unseen planet is there. If the mathematician through his instruments be thus sensitive to far-off matter in infinite space, may not the clairvoyant through her sensitile-projectile astral body be equally sensitive to a mass of silver?

"Once in a trance a finely organized adept or 'medium' wandered in her astral body through the open belt where the souls of the planets wander at will. While there she heard the comet-shriek, the cry of a lost planet soul, the most terrible sound that rings through the heavenly spaces of the zenith. Is not her testimony to be received with that of the other astronomers?

"From shore to shore across the Atlantic Ocean runs a metallic cable. By means of electric batteries, magnets and sparks, a message is conveyed from one end of this to the other. Messages have been sent so many times that the most sceptical can not doubt the fact. By such means a wanderer in any part of the world may be found and called home, or if need be, sent still further on. Most of us have seen this done and all have heard of it. Because it has grown familiar it seems real to us, and its mystery is dissipated. But why use the metallic cable at all? What occult power lurks in metal? Why must we work always on the material plane? Why not use the air? And indeed the air has been used and with wonderful success. But let us not stop here. Why not use the invisible ether, along which so many forms of energy are propagated? Why not use the boundless sympathy of life? In Europe there is a large species of snail which runs up and down the cabbages feeding on their leaves and is very fond of its mate. It too has been used in telegraphy. Leave your sweetheart in Italy when you come back home but leave her with a large piece of cardboard and take another like it for yourself. On each of these write a number of sentences of sentiment and affection—quotations from the poets, the finest possible to your literary taste, Browning, Tennyson, Wordsworth, or the latest topical song—any of these will do. Then take for yourself one of a devoted pair of snails, leaving the other with her. At an agreed moment (standard time, making allowances for differences of longitude) place your snail upon the card and she will do the same with hers. Your snail will creep to any sentiment you choose as you direct it. Hers is left free in its movements, but it will follow the same course that its mate has chosen. Thus the sweetest messages can be sent across the ocean. The last word of the snail in America, 'All's well,' or '*Non ti scordar di me,*' can be made to echo sweetly on a far-off shore. This is the *Parasilinic Telegraph,* no invention of mine, but the actual work of an ingenious 'psychic adept.'

"But why use the snails? Surely their cold slimy bodies are not more forceful than the throbbing heart and eager brain of man. Surely they are not more sensitive than his astral form. Let the snails go. They belong to the crude beginning of astral science. You have only to sit in your room alone in darkness, and by intense thought and irresistible volition you may set the whole ether of the world in palpitation with your dreams and desires.

"To your thought the 'sensitive' you love will respond. Her astral brain will register your ether throbs. 'It is my wish': that is enough for her. But you can do more than that, if we may trust the records. Your own astral body may be sent across the ocean on the tremulous ether and it will appear to her in her dreams or as part of her realities. While the absence of this body may be a slight inconvenience to you, for you must sleep or suffer while it is gone, it will be a source of joy to her. It may plead your cause for you in a way which protoplasmic bodies can never imitate. That this is not imagination or illusion we have abundant testimony, if the word of man unverified by instruments of precision is convincing to you. Thought and ideas, we are told, may be 'impressed on consciousness in solid chunks without waiting for words or clicks or other means of expression or for a lightning train to convey them,' and there are thousands of records to show how this is done.

"But you do not stop with the expression of your power over the ether and the astral messages it is the function of the ether to carry. You may exert control over matter itself. Mind is matter's king. Matter is the vassal of mind. Then under the force of mind, matter will change or vanish. Recent experimenters claim that by gazing at a photographic plate in the dark, an impression can be made on it. This is the mind flashing out through the human eye. Then whatever is in this 'mind's eye' should appear on the sensitive plate of the camera. But greater deeds than these were done long ago, as our honored president once pointed out, and to my mind they are told in records better authenticated. The sagas tell us that Odin wished to secure the golden mead of the giants that men might drink it and be strong as they. After great labors he came to the mead. He found that the giant Suttung had concealed it in a great stone house, to which Odin could get no key. So Odin and his friend the giant Bauge sat down before the house and gazed at its walls all day. By this means they made a small hole in the rock, and changing himself into an angle worm Odin entered the hole and at last carried the golden mead away in triumph. The influence of this golden mead is, no doubt, still potent in Odin's descendants whose glances have marvelous power.

"There was once a California nurseryman who had a good business and was making money, as the phrase is. So he put aside all the fruit trees which would sell and devoted himself to making others which would not. Each year he trimmed his plums and apricots and lilies and poppies, taking away the pollen which nature had provided and putting it on flowers to which it did not belong. Each year he planted thousands of seeds of many kinds, and when the plants came up, he pulled up nearly all of them and burned them in a great bonfire. Meanwhile he made no money, and lost little by little all that he began with. Then men began to see that all fruits and nuts and flowers changed under his hands. The plums grew very large and very juicy, red, blue and white and more on the tree than men had ever seen before. The lilies and the poppies and all the other flowers grew larger, the cactus lost its thorns and the onion its odor, the chestnut bore its fruit with its second crop of leaves and all things which he touched turned into something better or handsomer, and every year he pulled up nearly all that he had and burned it in great windrows. And foolish people said that he was a wizard and they came from great distances to see him at his work. And there were a few who thought that they understood.

"There was once an old white-haired man who came to an assemblage of scholars, bringing with him two bars of wood connected by bands of iron. Fifty-three years before he had left his home on the bay of Quinté, in Ontario, to show these bars to the world and to give to mankind what it never had before, control over 'The Unconditioned Force of the Universe.' This force through this little machine would 'revolutionize human industry, economize human labor and relieve human want.' 'Gentlemen,' said the old man, 'I gave up the free and easy life of the Canadian forests, I sought my home among the dwellers of cities, I have sacrificed fifty-three years of my life upon the altar of my desire to benefit mankind. In three weeks more my invention will be perfected and through these bars the unconditioned force of the universe will do its works for you and for me. The time has gone by,' he said, 'when the recognition of my principle would have pleased my ambition. I love my race, and I wish to do them good.' Two years more went by, the unconditioned force lacked but a few days—just one more week—of accomplishment, and in that week the old man died in the poorhouse of Monroe County, Indiana, and in the dust and cobwebs in an attic of a neighboring college the model of the machine to be controlled by the unconditioned force of the universe still awaits the touch which for the first time shall make it run; and there were some who called the old man a 'wizard,' and some a 'philosopher,' and because fame has forgotten his name, I speak it here—Robert Havens. And in both these cases, and in all cases, what is our test of truth?

"Not long ago, on the plains of Texas, by order of the government of the United States, tons of gunpowder were exploded. A great noise was made, the smoke arose to the skies, and then all was as before. The purpose of this was to produce rain under conditions in which common sense said rain was impossible. While these conditions remained there was no rain, but the wisdom of the experiment has the official stamp of the United States.

"Not long ago, and I am sure that the good people of Alcade will remember this, some enterprising men had bought the dry bed of a river in southern California. It is filled with winter floods in the rainy season, while in summer it is white with granite sand and barren stones. At best its boulders can only produce a scant growth of chapparal and cactus. Yet when it was announced that a city was to be built on this land, men grew wild at the thought. All night they stood in the streets of Los Angeles, each to take his turn in buying its town lots. And the people who bought these lots were guided in one way or another by what they termed their 'common sense.' The sense of great wealth was in the air, and even the wisest were carried away by it. 'The millionaire of a day' takes the breath of his brother millionaires.

"At Denver not long ago a man insisted that he had the gift of healing. A wild hermit from the plains; some called him crazy and some called him a prophet. But the gift he had, or seemed to have, and thousands of sick people and well crowded around him to be touched and healed. He could not touch them all so he blessed their handkerchiefs, and his power passed over to them. Men and women whose ills gallons of patent medicines had failed to assuage were healed at once by these pieces of soiled cloth. And testimonials such as they had once written for these same patent medicines, they now freely wrote for him.

"But, after all, is there such a thing as disease? Surely man 'made in the image of God' is made in the image of perfection, and what is perfect can not be marred or destroyed. May not disease be the greatest of illusions? May not all pain be a nightmare dream from which we should escape if we were once awakened?

"Many a school of healing has been based in one way or another on these propositions. In a hundred different ways at a hundred different times men and women have found that they could heal pain by the suggestion that pain does not exist. If pain is disease, then shall we not heal all diseases in this way? But some say that pain is not a disease, only a warning that disease is present or coming. Pain is the signal that something is going wrong in the mechanism of the human body. The signal may be unnoticed it is claimed. We then feel no pain but the injury remains, for it is the cause of the pain and not the pain itself. By persistently turning the mind away from these signals of distress sent up by the bodily organs, we may come at last to be incapable of receiving them. We are then free from pain, and our minds may be filled with a sweet serenity very satisfactory to ourselves. Now, which of these is true? Are we ill when we feel pain, well when we do not? Or do we feel pain because we are ill and does the illness pass when our feeling is gone? May it not be true that this is a dangerous and selfish serenity? If it does not mean the checking of disease, but only the closing of our eyes to its ravages, then have we really gained anything? To turn from pain is to turn from all outside impressions. To close the mind to the information given by the senses is to destroy reality, to make activity impossible, to cease to do our duty in the world. This is to cease to grow and to become a burden to our friends and a cumberer of society. There is nothing more noble than serenity amid trouble and distracting effort. There is nothing more selfish than the serenity which is bred by immunity from pain. But to many people, existence without pain, without sensation and without action represents an ideal of the soul. Many well-to-do women of leisure are devoting their lives to the cultivation of this condition, and incidentally neglecting their children and driving their husbands wild by the process. It is not alone faith in a theory of disease or a theory of non-existence which may produce this result. Faith in a celery-compound, an electric belt, or a mud idol may produce the same sweet serenity, the same maddening indifference to all that is real or moving in life. The walls of certain churches in Mexico are covered with the offerings and pictures of those who were saved by their vows or by appeals to some saint. 'But where,' said Lord Bacon, long ago, 'are the pictures of those who were lost in spite of their vows?'

"It is true that to cultivate a cheerful temper, to look on the bright side of things, to laugh when we can and be hopeful under all conditions is good for the body. The food is better assimilated, the blood runs faster, one can do more and better things, and come in closer relations with the realities of life. But conversely, when one meets most manfully the needs of life, his pulse beats more quickly, his brain works better, his liver gives him less trouble and he is naturally cheerful and hopeful. The cheerful man does not dodge pain, he overcomes it. He does not selfishly shrink from reality and turn to introspection and dreaming. He faces the world and makes it his own and takes manfully the pain his efforts cause or which in the progress of life he can not avoid.

"It is possible to go much farther in the direction of the banishment of pain through the thought that pain does not exist. Then take more pain and it will become at last an intense pleasure; when the mind is in the grasp of absolute torture, it is possible for the brain to feel it as with spasms of absolute delight. It is not easy to do this but can be produced by excessive belief in the unreality of common things. The brain half-maddened by pain is open to suggestions from other maddened brains till a fierce wild ecstasy is the final result. This fact explains the strange rites of those sects of self-destroyers which rose in the middle ages, the flagellantes, penitents and the rest. Even yet, the last of the penitent brothers at San Mateo in New Mexico in the passion week torture themselves in the most revolting fashion by crucifixion, whipping and the binding of huge cactuses on their backs. By hideous tortures they expiate in one week their many heinous sins of the whole year. Just as the suggestion that disease is an illusion may conceal pain, for those who give up everything else for healing, so does the suggestion of infinite pleasure conceal for a time the most exquisite pain. But in the one case, as I believe, the disease goes on unchecked, so in the others, the wounds of the whip and the cactus stab remain as realities when the illusion of joy has passed by.

"In Orange County, California, there is a religious sect which finds the old Bible of our race, the Bible of Moses and Job and Jesus and Paul, an outworn book, no longer fitted for the aspirations of man. This bible is still tinctured with the gospel of selfishness, for it recognizes private ownership of land, and goods and men. 'To honor thy father and mother' implies special ownership of them, and the higher life demands that there should be no respect of persons. There can be no personal claims of any sort if all are to be as 'angels in heaven.' Its command 'thou shalt not covet thy neighbor's goods' implies the neighbor's ownership of material things, a relation which must degrade all who submit to it. 'To render unto Cæsar the things which are Cæsar's' is an outworn recognition of powers that be but which ought not to be. Clearly a new bible is needed, and one of the members of the sect sat down by a typewriter (presumably not his own property) and wrote a bible. It was not his own composition, but that of the Almighty, for the writer simply lent the hands with which divine power did the work. As his fingers played over the Remington keys, he thought of anything or everything except his writing. The result was the book of Oahspe, the Bible of this new dispensation. And the name of the book arose naturally. One looks up to Heaven, and he says 'Oh,' then he looks down to earth and says 'Ah,' and between Heaven and earth is Spirit,—Oahspe!

"In the City Park of San Francisco is the wooden image of some monstrous creature carved by the Indians of Queen Charlotte Sound to express some phase of their mystic devotions. This image was stolen by a Norwegian sailor. Its makers resented its loss by a series of incantations so horrible that they took effect in the image itself. The idol came to San Francisco, bringing sickness, shipwreck or failure to all who touched it. Even now while it rests on a shelf in the Park Museum in apparent quiet, its evil power is shown at night in the smashing of vases and the overturning of bottles. Something of this kind takes place whenever the image is left unguarded. A man who had charge of it for some time avers that one night the creature rose up in living form and seized him in its clutches, and only by the most violent efforts could he make his escape.

"When an electric current, whatever that may be, is passed through a glass tube from which most of the air has been exhausted, various peculiar phenomena are shown. There is an appearance of bluish light, and from certain parts of the apparatus peculiar rays are given off which do not appear as rays at all. Ordinary light rays pass readily through water, glass or crystal, and we call these objects transparent. Through wood or cloth or stone they will not pass; hence these objects are said to be opaque. And the rays of light may be diverted from their course by passing at an angle from one transparent body to another. This property, known as refraction, is the cause of the formation of images by convex transparent bodies or lenses. But, strangely, the rays of light above mentioned do not act like ordinary light. All objects are transparent to them, though not in equal degree. Not being stopped by dense bodies they are not refracted. Not being affected by lenses they do not produce vision in the eye. As we can not see them to the eye they are not light. But their effect on chemical decomposition is the same as that of light. Hence while not available for vision they can be used in photography. But not being refracted they produce no definite image on the sensitive plate. But they may give rise to shadows. They do not pass through all opaque objects with equal readiness. Hence to place an opaque body between the rays and a sensitized plate would be to cast some kind of a shadow on that plate. The shadow means an arrest of the chemical changes which are the basis of photography. Then if the opaque body be not in all parts of equal density the shadow becomes deeper in some places than in others. This gives on the photographic plate some idea of the intimate nature of the object photographed. For the density is not merely a matter of the surface of bodies. It pertains to the interior, which in an opaque object can not be seen, but which nevertheless may be photographed in this fashion by these peculiar rays.

This line of investigation was lately developed in experiment by Professor Röntgen, and the strange character of the 'X-rays' or 'cathode rays' is now a matter known to every one. By means of these non-refracting rays, shadow photographs can be made showing the bones of the skeleton, imbedded bullets, the contents of a pocket-book, or any similar hidden object which has a nature or a density unlike that of its containing surface. These experiments of Röntgen have been varied and verified in every conceivable way. A wonderful mythology is growing up around them, to the confusion of those who have not paid attention to the series of experiments which made Röntgen's discoveries simple and inevitable.

"For example, in a thousand places the Röntgen rays and the bacilli of disease are made to work together to fill the purse of the enterprising physician. The doctor examines the internal organs of the patient with the fluorescent tubes. He finds out how and where the germs of disease are working their devastation. Then he turns the mysterious X-rays upon these germs and they are checked in their career of ruin: shrivelled up, it may be, under this marvelous light, as caterpillars shrivel on a hot shovel. Another physician I know of distributes his remedies by electric wire, one end in the bottle and the other in the mouth of the patient, miles away. Still other physicians, wise in their generation, use the X-rays and the microbes and the electric currents with other mysterious agencies equally for their own profit or comfort. Now that the X-rays have become somewhat familiar and matter of course, the still more wonderful emanations of radium are made to do the same things and in a fashion equally regardless of the lessons of chemistry and of physiology. The medicine man of the Modocs by other incantations of his own calls up the microbe of disease which he finally spits out, a trout perhaps, or a wood-boring grub or a small lizard—from his own mouth. There have been occult and esoteric methods in medicine since the first Old Man of the Mountains learned to look wise. The rabbit's foot for good luck, the cold potato for rheumatism, celery for the nerves and sarsaparilla for the blood are typical methods as old as humanity. But quackery and pretense does not diminish our debt to honest medicine and surgery however much it may tend to obscure it. Some one asked Dr. Mesmer, the great apostle of animal magnetism, which was the form taken by 'faith cure' in the last century, why he ordered his patient to bathe in river water rather than in well-water. His answer was that 'the river water was exposed to the sun's rays.' When further asked what effect sunshine had other than to warm the water he replied, 'Dear doctor, the reason why all water exposed to the rays of the sun is superior to other water is because it is magnetized—since twenty years ago I magnetized the sun!'

"I see in the Alcalde *Gazette* that Madame de Silva, a prophetess and seer of visions, seventh daughter of a seventh daughter, born with a caul, down at the American House, is prepared to diagnose all diseases from the examination of a lock of hair, and that Wong Chang, the Chinese doctor, is prepared to do the same and ask no questions. How does this differ from the power of Cuvier to draw a bird from a simple claw or that of Agassiz who could restore a whole fish from one scale?

"Throughout the middle ages experimenters of all grades were engaged in the task of finding the means by which base metals could be transmuted into gold. It was possible in the chemical laboratory to do many things which seemed equally difficult and to the common mind far more mysterious. In the philosophy of the day, and perhaps in our own time as well, there was every reason to believe that the transmutation of metals was possible. But it never was accomplished and many a learned alchemist went to his grave, the work of his life a confessed failure.

"Yet this very day, the daily press, which is responsible for so much of spurious science and mental confusion, gives the record of successful alchemy. One famous metallurgist of world-wide reputation (all these men have 'a world-wide reputation with one another'), has subjected silver to great pressure till it becomes yellow, soft and heavy just like gold. All the difference is in the density—16 to 1. Condensed silver is gold, so the newspaper maintains, and the problem of alchemy is solved at last. By these experiments, six ounces of silver make but four ounces of gold, one third of the substance being somehow lost in the process. But with improved appliances this third should be saved and the finances of the world may be reconstructed on a basis of genuine bimetallism, gold being made when wanted from the condensation of silver. Yet all-important as this discovery should be, neither chemistry nor finance pays any attention to it. It belongs to the science of the newspaper having only the validity of a 'fake advertisement.' 'Common sense' demands that the experiments be verified and the steps which led to them be made known before considering for a moment the probability that there is any truth in the newspaper statement.

"Now how amid all the wonders of science, non-science dreaming, fakery and insanity is the common man to find his way? How shall he recognize the claims of science among all the other voices and noises in this vociferous world?

"This is my answer, and I believe that it is the answer of science. As to many things the common man may not know at all. Where he is not concerned in any way so that error and truth are alike to him because they can not affect his action, he may be powerless to decide. It is not always important that he should decide. 'I do not know' is the affirmation characteristic of the wise man. It is safe to believe mildly in mahatmas and norms and hoodoos and voudous if one does not regulate his life according to this belief. The vague faith in protoplasm, in natural selection or in microbes which the average man possesses will serve him no better if it is put to no test. The difference appears when one acts upon his belief. The nearer one's acquaintance with molecules or protoplasm, the more real and more natural do they appear. The microbe is as authentic as the cabbage to one engaged in dealing with it. Protoplasm is as tangible a thing as wheat or molasses. But the astral body and the telepathic impulse become the more vague the nearer we approach them. They are figments of the fancy, and their names serve only as a cover for our ignorance of the facts. The charm of such words as Karma, Avatar and Kismet lies in the fact that most of those who use them have no idea of what they mean. Lack of meaning or ignorance of meaning lies at the foundations of most occultism. Scientific induction in its essence is simply common sense. The homely maxims of human experience are the beginnings of science. To know enough 'to come in when it rains' is to know something of the science of meteorology. By scanning the clouds we may know how to come in before it rains. By observing the winds we may tell what clouds are coming. By studying the barometer we may know from what quarter the winds and clouds may be expected.

"The discoveries of science are made by steps which are perfectly simple to those trained to follow them. No discovery is made by chance in our day. None come to contradict existing laws or to discredit existing knowledge. The whole of no phenomenon is known to man. The whole truth never can be. Ultimate truth was never in any man's possession. The unknown surrounds on all sides all knowledge in man's possession. The beginning, the end and the ramifications are beyond his reach. He was not present when the foundations of the universe were laid. He may not be present when they are destroyed. But scientific knowledge, though limited, is practical and positive so far as it goes. It rests on experiment and observation alone. Every step in observation, experiment or induction has been tested by thousands of bright minds. He is already a master in science who can suggest even one new experiment. There is nothing occult or uncanny in scientific methods. The 'magic wand' which creates new species of horses or cattle lies in the hand of any stock-breeder. The magic key of the electrician by which the foam of the cataract becomes the light of the city may be held by any municipal council. To take the illustrations given above, 'there is such a thing as a squash,' because the assumption that the squash exists constitutes a safe basis for action. On that hypothesis you can plant squashes or raise squashes or make them into pies. The brightness of the brandy-colored world we can not trust. It requires no scientific instruments of precision to record the failure of the man who guides his life on a basis of impressions made by drugs or stimulants.

"The transit of Venus is no product of fancy. To the astronomer the coming of the planet between the earth and the sun is as certain a thing as the coming of the earth into its own shadow at night. The one incident is more common than the other, but not more mysterious. And to go to that part of the earth which is turned toward the sun at the moment of transit is the simple common sense thing to do if one wishes to see the transit. The island, the abandoned hut and the cooking utensils were only incidents to the astronomer. To the natives these were the only realities and the purposes of sciences were to them unknown or absurd. To the man of common sense the digging for treasure under the direction of clairvoyants seems ridiculous. The operation does not become more wise when we see it through the eye of science. Tested by instruments of precision, 'clairvoyance' becomes a myth and such truth as its phenomena contains is explainable in simple ways.

"The spectroscope grows more real and more potent as we study its methods and results. The divining rod is only successful through ignorance or fraud. The process of weighing planets is open to all who will continue their studies till they understand it. The test of knowing is doing. The oceanic cable in the service of all who have concerns in another continent. It hides no mystery save the one eternal mystery of matter and force. The phenomena of telepathy have fled before every attempt at experiment. The study of the 'X-rays' is as far from occultism or spiritism as the manufacture of brass is from the incarnation of mahatmas. The mind healer, the faith healer, the curative theories of 'neminism,' the sale of the patent medicine, the medical marvels of radium, the wonders of the electric belt and the power of animal magnetism are all witnesses of the potency of suggestion in the untrained mind. To the same class of phenomena the witch-hazel rod belongs. Experiment shows that its movements are the involuntary muscular contractions and that these follow simply the preconceived notions of the holder of the rod.

"If, as some one has lately said, all men sought healing from the blessed handkerchief of the lunatic or from contact with old bones or old clothes, if all physicians used 'revealed remedies' for the remedies nature suggests for each disease, if all the supposed 'natural rights' of men were recognized in legislation, the insecurity of such actions would speedily disappear. The long and bloody road of progress through fool-killing would for centuries be traversed again. Without the instruments and methods of precision which belong to science we should find ourselves in the weakness and babyhood which was the heritage of the common man through the middle ages.

"In the degree that 'organized common sense' or science, has been a factor in the lives of men and nations, men and nations have been happy and effective. The ultimate function of science is the regulation of human conduct.

"Not long since one of our sciosophical friends proposed the theory that the chemical elements were each of them forms of 'latent oxygen.' This theory he defended by the argument that the business of science was to propose all sorts of theories. As some apples on a tree will be sound so will some of these theories be true. To make every conceivable guess is the way to hit on the truth. Some such notion as this is common among cultured people of all countries. To accept it is to ignore the whole history of science. No advance in real knowledge has come from guessing, dreaming or speculating. If we want a picture taken we find a man who has a camera and who knows how to use it. If we want the truth on any subject we must find a man who has the instruments or methods of precision and who knows how to use them. There is no other way. As well expect a man without a camera and who knows not how to use it if he had one to take a photograph as to trust to a speculator, guesser or dreamer to find the truth. To work without tools, in the world of objective reality, can yield only illusion and fraud."

At the conclusion of the address, President Marvin expressed the thanks of the Astral Club for the bold and straightforward declaration of materialistic principles. But at the same time he could not refrain from reminding Mr. Grimshaw that he was still very young and that there were many things in heaven and earth and Devachan which are not yet taught in the schools.

IS MAN AN AUTOMATON?

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FEW things are more irritating to the average man, who does not pretend to be a philosopher or a scientist, but respects the opinions of such, than to be told, by those whose word seems to carry authority, that he must regard himself as an automaton.

He has been accustomed to consider his own mind and the minds of his neighbors as of no little significance in the system of things. He says that he rose early, because he knew he had a long day's work before him; he took his bath, because he knew it was good for his health; he went to the dining-room, because he wanted his breakfast; he ran for the train, because he did not care to lose five minutes waiting for another; he whistled, that the conductor might hear him and might be induced to delay a moment; he climbed the stairs to his office, because the elevator seemed to be intolerably long in coming.

So it went all through the day. He did things because he wanted to, or because he thought he had to. Other men about him did things for the same reasons. His whole day seems to have been full of thoughts and feelings, plans and decisions; nor can he bring himself to believe that, had these been different, his actions and those of other men would have been what they were. So unequivocally does his experience appear to testify to all this, that it does not even occur to him to raise a question, until some professional questioner suggests a doubt.

But he spends the evening of such a day in his library, and, as he turns over the pages of certain volumes of scientific essays, his eye is caught by Professor Huxley's statement that "our mental conditions are simply the symbols in consciousness of the changes which take place automatically in the organism." If he is startled by this, his mind is by no means quieted when he turns to Professor Clifford and reads: "Thus we are to regard the body as a physical machine which goes by itself according to a physical law, that is to say, is automatic. An automaton is a thing which goes by itself when it is wound up, and we go by ourselves when we have had food."

To be sure, each of these writers softens the blow somewhat. Huxley tells us that we are *conscious* automata; and Clifford says that the body is not *merely* a machine, because consciousness goes with it. Nevertheless, this does not seem to make good the previous wrong. If a man tells me that I am an imbecile, and then modifies the statement by adding that I am a particular kind of an imbecile, it still rankles in my breast that I am an imbecile; and I am naturally impelled to inquire into the justice of applying the title to me at all. I may not call a young lady a doll, and then soften the blow by explaining that I have somewhat extended the signification of that common word. One has a right to ask: Is the word, when so extended in meaning, rightly applied at all? Are dolls that think and speak, feel and will, and all the rest, really *dolls?* If not, why use the word, except as a figure of speech, and with insulting intent?

Now, it would be absurd to maintain that Huxley or Clifford or any other serious adherent of 'the automaton theory' has written with the intention of insulting or degrading mankind. These men had a glimpse of what they regarded as a valuable scientific truth, and they urged it upon the attention of their fellows. In doing so, however, they made use of expressions which have actually given offence to many, and have predisposed men to a rejection of their doctrine. I feel like going further and saying that the mere fact that they have seen fit to use such expressions may be taken as an indication that they have not fully grasped the significance of the truth they were endeavoring to express, but have themselves slipped into a misconception, which has harmed their cause.

I may say at the outset that I regard the cause as a good one. This does not in the least mean that I believe in any 'automaton theory.' The name is a grotesque and an offensive one, and should never have been used. The plain man is quite right in refusing to regard himself as an automaton. The real cause for which the so-called automatists, have been fighting is a clear and unambiguous conception of the relation between the mental and the physical—one which will not rub out the distinction between the two, but will do it full justice. In the present paper I shall try to show that the frank acceptance of their fundamental thesis need not make a man an automatist at all; nor need it compel him to modify the estimate which his experience has led him to form of the significance of men's actions. In other words, the man may become as 'scientific' as he pleases, without on that account being forced to repudiate common sense and common experience. Surely this is no small gain.

We all have experience of the relations which obtain between mind and body, or we should not even know that we have minds and bodies. But those who have not devoted special attention to psychology and philosophy are apt to have the vaguest of notions as to what the relations in question are. We have, to be sure, gotten beyond the crude materialism that once led men to regard the mind as consisting of five round atoms, disseminated through the body, and inhaled from the atmosphere. But I am not sure that most persons would not be inclined to maintain that the mind is *in* the body 'somehow'—and when we inquire into the significance of this 'somehow,' we can scarcely fail to discover that it has a material flavor. Whether rightly or wrongly, most men think of the mind as in the body in somewhat—but only somewhat—the same way as material atoms may be in the body. And he who thinks of the mind in this way may, if the question occur to him at all, assume that mind and body interact *somewhat* as two material things interact with each other.

To be sure, the more one reflects upon the difference between mental phenomena and physical, the more vague and indefinite this 'somewhat' seems to become. Material things can lie beside one another in space; they can approach one another and recede from one another. Their interaction is a thing to be described in physical terms; we have to do with space and motions in space. Have we anything analogous to this when we are considering, let us say, the mental image of a railway station and those physical changes in the brain which antecede my moving my feet in the direction of the station? Is the mental image literally *in* any part of the brain? Can it approach or recede from any group of molecules? Does it mean anything to say that it lies *between* this physical occurrence and that? And if the relation between what is mental and what is physical is really so different from the relation between two physical things, must we not recognize that the word 'interaction' is ambiguous when it is applied indiscriminately to either relation?

As early as the seventeenth century reflection upon the differences which distinguished the mental and the physical led to the conclusion that it is impossible that ideas should be inserted as links in any physical chain of events. You can not plant an imaginary tree in a real ten-acre lot; you can not insert the thought of a cork into the neck of a real bottle; is it more sensible to say that the thought of a railway station may be inserted as a link in a series of changes in the nervous system of a man? To such men as Huxley and Clifford it seemed that the physical series must be regarded as unbroken. Clifford, much influenced by the philosopher Spinoza, describes the relation between physical changes in the brain and the accompanying ideas as a 'parallelism,' as a correspondence or concomitance. It is scarcely necessary to add that neither he nor any later parallelist has intended the word 'parallelism' to be taken literally. It only means that mental phenomena are to be regarded as excluded from the series of physical changes, and yet as accompanying them.

Now, I think we may leave out of consideration those who endeavor to steer a middle course—to eat their cake and, at the same time, to keep it. The question is: Is the series of physical changes to be regarded as unbroken, and are mental phenomena to be looked upon as the invariable concomitants of certain physical changes; or are the two classes of facts to be built into the one series? Those who accept the first alternative are *parallelists,* and those who accept the second are *interactionists.*

Naturally, there is a lively quarrel between the two sects. The parallelist insists that the interactionist has no clear notion of what he means by interaction, when he uses the word; and he maintains that, did the interactionist realize his position, he would see himself to be little better than a materialist. He has failed to recognize the great distinction between mental phenomena and physical. On the other hand, the interactionist insists that the parallelist, in declaring the series of physical changes to be unbroken, has reduced the mind to a position of utter insignificance. Every action can be accounted for by going back to its physical causes, and to those alone. The mind, then, is a mere decoration; it does nothing; the man is a physical automaton, etc., etc.

I am not going to try to persuade any one, in this paper, to become an adherent of either the one sect or the other. But it does seem rather hard that those who watch the combat should be led to suppose that, with the triumph of the one party, they are condemned to become materialists, and, with the triumph of the other, they are turned into automata. It is distressing to be confronted with Scylla and Charybdis, and to see no clear water between.

What I wish to prove is that the whole matter is one to be regarded with no other emotion than that of intellectual curiosity; and that it does not matter a particle to the plain man, from the practical point of view, which side wins.

First let us assume that the interactionist is right. Then ideas and motions in matter may be regarded as belonging to the one series—they are links in the one chain. Now, one can not piece out a defective series of sounds by the insertion of a smell; one can not, when one tree in an avenue has died, replace it by a tree in a dream. To constitute a series, in any significant sense of the word, things must have something in common; it must *mean* something to speak of gaps and insertions. Let us suppose, for the sake of argument, that it does mean something here, and that ideas are enough like motions in matter to be inserted between certain motions in matter and to form one series with them.

This may be a form of materialism; but what of that? The man whose day has been full of ideas, of desires and volitions, of plans and purposes, has had just the day that he has had; and the fact that all these are called material or semi-material does not prevent their being just what he has experienced them to be. If some material things can be like this, and can play such an important part in his life, he should get over his repugnance to materialism, or at any rate to some sorts of materialism; and he may go on thinking and talking about himself and his neighbors much as he has thought and talked in the past. It is not worth while to be frightened by a mere word; a cold in the head is not made worse when it is given a Latin name.

It may be said, it is a waste of time to try to protect men against the fear that interactionism may be proved true, for men have no dread of this result, as it is. This I think we must admit. Those who are familiar with the history of psychology and philosophy know that there was a time when it was not repugnant to men to conceive the mind as literally a kind of matter, having its place in the body just as any other kind of matter has its place. Gradually it came to be felt that this was a misconception, and various curious attempts were made to describe the mind as immaterial. To-day nearly every one is willing to say that the mind is immaterial—the conception has become common property. Nevertheless, he who is clear-sighted can see that most men have not wholly stripped away materialistic suggestions inherited from the past; and he finds these embodied in the interactionist doctrine. As, however, interactionism does not ask the plain man to be more materialistic than he is naturally inclined to be—every one can find a comfortable seat in so roomy a place as a 'somehow'—it does not arouse his apprehensions. So I shall not spend more time in allaying fears which do not arise in most minds, but shall turn to the 'parallelist' doctrine. Its supposed terrors constitute our proper theme.

Let us suppose that the parallelist is right. Then ideas and motions in matter must be regarded as belonging to two distinct series, and they must not be made links in the one chain. Thus, a pin is thrust into my leg; I reach down to it and pull it out with my fingers. A series of changes has taken place in my body. Some message has been sent from my leg, along certain nerves, to the brain, and a message has been sent along other nerves to the muscles of my arm and hand. But this does not say everything. I have felt a pain; I have been conscious of the injury done my leg; I have wished to remove the pin; I have resolved to do so, and am conscious that I do it. The physical series is an unbroken one; the mental phenomena are concomitants of brain changes, but fill no gaps between them.

Now, if we admit all this, must we sadly accept the following doleful results?

1. Man must be regarded as an automaton.

2. Man's mind is insignificant; as his body does all that is to be done, we may say that the result would have been the same had he had no mind.

3. Hence, we ought to abandon our usual ways of thinking and speaking about ourselves and others.

If these results actually do follow from an acceptance of parallelism, men may well feel apprehensive when they see able men advocate it. If none of them follow, there is small cause for apprehension, and the question becomes one of merely scientific interest.

Let us consider the first point. Must the parallelist regard man as an automaton?

Before one can decide this point intelligently one must know what the word 'automaton' means. He who consults his dictionary is informed that it means 'that which is self-moving, or has the power of spontaneous movement, but is not conscious.' A little lower down it is explained to him that the term more specifically denotes 'an apparatus in which the purposely concealed power is made to imitate the voluntary or mechanical motions of living beings, such as men, horses, birds, fishes,' etc. He is further given to understand that the word may be applied to 'a person or an animal whose actions are purely involuntary or mechanical,' or to a person who acts 'without active intelligence, especially without being fully aware of what he is doing.'

Do any of these definitions cover the case of the man described in the first paragraphs of this paper? Was he without consciousness? Was he constructed to imitate the actions of a living being? Were his actions involuntary? Did he go through his day without active intelligence? Yet the definitions are very fair, and do not misrepresent the actual use of the word defined. Even in psychology, when we speak of 'automatisms,' we never have in mind a shrewdly planned raid upon the bourse, or the production of Cæsar's 'Commentaries.'

The fact that I choose to pin my faith to one view of the relation between mind and body rather than to another gives me no right to wrest words from their proper uses and to employ them in ways that must be misleading. Normal man is not an automaton in any legitimate sense of the word; and it is a grave injustice to parallelism to call it 'the automaton theory.' To be sure, Clifford and others have invited the injustice which has been visited upon them, and we can scarcely pity them as much as though it were wholly unmerited. But the frankest adherence to their parallelism need not induce us to call man an automaton. To say that consciousness is 'parallel' to brain changes is not equivalent to saying that consciousness is not present at all, or is present in defective measure.

And now for the second point. Must the parallelist regard man's mind as insignificant, and say that his actions would be the same if he had no mind?

Surely not. Bear in mind what parallelism maintains. It maintains that mental phenomena and certain cerebral changes are *invariable* *concomitants.* This means that a given idea can not exist unless there is a certain brain-change. But it also means that the brain-change in question can not possibly exist unless the corresponding idea exists. The relation between the two is not conceived to be an accidental one. For reasons which have been indicated, the parallelist objects to calling it a causal relation, and prefers the word 'concomitance.' Nevertheless, he regards the relation as one on which we may depend absolutely—as absolutely as we can depend upon the relation between a physical cause and its effect.

But, if this is so, the plain man may perfectly well become a parallelist and yet go on talking as though certain results could not be brought about in the absence of minds. He is quite justified in maintaining that no clever book could ever be written, no such day as his has been ever lived through, by a creature without a mind. He may, if he choose, leave to the scholar by profession the question whether the word 'cause' is not somewhat loosely used in common life. What he cares about stands firm on any hypothesis: ideas *are* significant; if he can work out a satisfactory plan in his mind, desirable results will be achieved; if he has not the ideas, the results will not follow.

Now for the last point. Should the parallelist abandon our usual ways of thinking and speaking about ourselves and others? It must be admitted that the words used by some parallelists suggest, at least, that he should do so.

"An automaton is a thing that goes by itself when it is wound up, and we go by ourselves when we have had food." The suggestion certainly is that, if we want men to function, we should feed them.

It has been known, of course, from time immemorial, and in every country under heaven, that men who get no food at all will soon cease to go; and it has been known also that men who get too much drink will first go irregularly and then not at all. It is an old secret that what goes into the mouth of a man is not a matter of indifference.

But did any man, parallelist or interactionist, ever try to control the actions of his fellow man in detail by the giving of food? or try to explain why Mrs. Smith visits Mrs. Brown and neglects Mrs. Jones, by investigating the diet of that discriminating lady? We can not explain her taking the longer walk through the park rather than the shorter one along the street, by pointing out that she has legs. If she were unprovided with these members, she would undoubtedly not walk at all; but her having them does not enlighten us as to her choice of a walk, nor does it give any key to the control of her actions.

Clifford himself never tried to make men 'go' by the administration of food; he wound them up by public lectures and by printed essays, when he wanted them to think as he did and to act as he wished them to. The truth is that the brain-changes which correspond to mental states are unknown; we have not the least conception how the brain-change of a man meditating a gift to a hospital and that of a man planning to rob a bank differ from one another. Nor have we any direct physical means of producing either. But we do know a good deal about men's minds, and we know how to arouse in them ideas which will—directly or indirectly, it does not matter which—result in definite actions.

The plain man is, then, quite right in explaining his day by a reference to ideas. We have no other way of explaining it. There is no reason for changing our usual modes of expression. The parallelist who calls himself an automatist, or who talks of winding men up by the administration of food harms his own cause gratuitously. There is nothing in parallelism, properly understood, to cause apprehension; and there is nothing about the doctrine that is startling.

It seems right that, having criticized that very clear and charming writer, Clifford, I should close with a word in his defense. It is very easy, when a doctrine is relatively new, and has not been subjected to careful criticism, to misconceive its full significance. Were Clifford alive to-day, I do not believe that he would call man an automaton at all. He would see, I think, that it is misleading to speak so. But he would still be a parallelist, and he would gain the more adherents to his interesting scientific hypothesis, in that his utterances would be less calculated to shock the common sense of his fellow men.

A VOCABULARY TEST

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I

OF all the inventions of the human race nothing compares in importance, as regards mental development, with language. In the development of each person also, nothing exercises a greater influence in molding and developing thought and feeling than his language environment. 'The vocabulary of a person represents in a condensed and symbolic form all that he has experienced and imagined. The breadth of his mental experience is indicated by the number of words that have for him a meaning, while the accuracy of his thinking is shown by the constancy and exactness of meaning with which he uses words.' The study of vocabularies ought therefore to be an important branch of psychological investigation.

Studies have been made of the number of words used by great writers, and by children a few years old. The latter studies have shown that a child may not use words that are perfectly familiar to him for months merely because he has no occasion to use them, *e. g.*, words frequently uttered in the summer or when in the country may never be used in the city or in the winter. Adults are familiar with many words that they have rarely, perhaps never, used. The difficulties in the way of counting accurately the number of words *used* by an adult or even by a child over three years of age are almost insurmountable.

When we attempt to estimate the number of words that *have a meaning* for an individual, the difficulties are less although the number of words is much greater. The writer long ago estimated the number of words in his own vocabulary by going carefully through an unabridged dictionary and counting the number of familiar words on every tenth page (see *Science*, O. S., Vol. XVIII., pp. 107–108). Since then he has often had his students estimate the number of concepts that they possessed by counting the number of words that had for them a fairly definite meaning, on a few pages of the dictionary, and then calculating from the proportion of familiar words the total number of words they knew.

When a student began, say on page 2, and counted all the words in bold-faced type and the number of these known on every fiftieth page, and then did the same beginning with page 20, the results were so nearly the same as to convince me that the method was fairly accurate. Some preliminary tests were then made that showed that a hundred words taken by chance from various parts of the dictionary might serve as a fairly accurate measure of the size of one's understanding vocabulary. The words used in the final test consisted of fifty words taken from the first four words on every fiftieth page of Webster's academic dictionary and fifty words from the first of other pages leaving out different forms of the same root word (*e. g.*, photograph, photographer). This was done with the thought that older persons might be able to infer better the meaning of unfamiliar words than younger persons. The results were negative and the author now considers that the best list of words is obtained from Webster's academic dictionary (which contains about 28,000 words on 645 pages), by taking the first, second, or last word, or any other definite word on every sixth page. For general purposes and for all ages this is probably better than to take a hundred words from an unabridged dictionary which contains so many various and obsolete forms of the same words, along with rare words, and technical terms not found in the smaller dictionary. Estimates based on words from the academic dictionary give less than half as many words in the vocabulary as those based on data from the unabridged, but they are more representative of fundamentally different concepts.

The method of using the test was to place the printed list before the subjects and ask them to mark the words that they knew with a plus (+) sign, those that they did not know with a minus (—) sign, and doubtful ones with a question mark (?). The tests which numbered about two thousand were made chiefly upon pupils from the fourth grade up through the high school and university, although a few were made upon younger children. Control tests showed that if the same test was given orally, there was some difference in the words marked as known and unknown. This difference was of course very great in the second and third grades, where a few tests were made, and became less with age, yet it usually amounted even in the case of adults to from one to three per cent. In a few individuals the difference was quite marked.

The reason for this is that some words are more often heard than others, while others are more often seen, hence in one case the auditory stimulus arouses familiar associations while in the other case the visual stimulus is more effective. In general the auditory stimulus is more effective for children, but, as they read more, the visual stimulus becomes more effective and later many words are seen that are rarely or never heard; hence for such words the visual stimulus is the most effective and sometimes the only stimulus which will produce the reaction of familiarity. The test is more accurate if both forms of stimuli are used, *i. e.,* the words pronounced as the pupils look at them.

There is another cause of difference and also of inaccuracy. In the auditory test unfamiliar words are often mistaken for familiar ones having a similar sound, *e. g.,* barque for bark, baron for barren, and in the visual test similarity of appearance plays a similar part. A striking case of this form of error was made by a third grade boy who marked the word amaranth as known. I said to him, 'You don't know that word, do you?' He said, 'Yes,' in a tone that implied surprise that I should question it. I then said, 'What is the word?' He replied, 'Arithmetic.' Another boy for similar reasons, partly visual and partly auditory, marked 'eschar' as known and when questioned called it 'sister.'

On the other hand, young children often do not mark words that are perfectly familiar to them, because the sounds and forms without any other stimuli of suggesting words or circumstances are not sufficient to immediately arouse the sense of familiarity. One second grade boy who marked only eighteen words in the test, when questioned, showed by synonyms or definitions, or illustrations, that he knew the meaning of thirty of the words.

Individual habits of thinking or judging is probably the largest factor in tending to make the marking of words an unreliable index of the actual mental furniture of the subject of the test. Some mark as known every word that arouses the feeling of familiarity, while others mark as known only those for which they are confident they can give a correct definition. The differences in this respect are, however, most shown in the doubtful marks while the plus mark usually means the arousal of a specific idea by the word form. This idea may be vague or distinct, narrow or broad, general or detailed, correct or incorrect, but it is the idea usually aroused by the word.

Upon defining a list of words to a class of normal students after they had marked them, it was found that the errors in marking words as known and unknown usually cancelled each other, so that the number finally reported as known and unknown was for most members of the class about the same as when they were first marked.

Instruction as to what shall be the standard for deciding whether a word is known, such as "Count as known all words that you would not, as to their meaning, need to look up in a dictionary if you saw them in a sentence," helps to render the marking more uniform. Another and more accurate method of bringing about uniformity of standard is to ask the pupils to define or put in sentences some of the words, then to mark the rest according as they think themselves able or unable to indicate their meaning.

If students are asked to define a certain proportion of the words as accurately as possible, giving all meanings where there are more than one, depth and accuracy as well as breadth of knowledge may be tested. In college classes where twenty of the hundred words were defined, 114 out of 246 students were found to have defined the same proportion of words that they marked as known and only seventeen showed a difference of as much as three words of the twenty from the corresponding proportion of the hundred words marked. The over-estimations slightly exceeded the under estimations.

The author is convinced that one hundred words selected as has been described and marked with care gives sufficient basis for an approximate estimate of the size of the understanding vocabulary of college and high-school students, and of the higher grades of the grammar school. In the author's own classes where students were ranged in three grades according to the number of words marked as known in one list of words, other lists of words similarly selected resulted in 60 per cent. to 80 per cent. of them being again in the same grade, while none were changed from the lowest to the highest grade.

Using Webster's Academic Dictionary as a basis it appears from averaging about two thousand papers that the size of vocabularies are likely to approximate the following:

Grade II	4,480	Grade III	6,620
Grade IV	7,020	Grade V	7,860
Grade VI	8,700	Grade VII	10,660
Grade VIII	12,000	Grade IX	13,400
High School.			
Freshmen	15,640	Sophomore	16,020
Junior	17,600	Senior	18,720

The average for normal school students is 19,000 and for college students 20,120. The colleges represented in this test were Bryn Mawr, Smith, Columbia, Brown University and Pratt Institute, while the grades and high schools were mostly in Massachusetts cities.

There seems to be no constant difference between the sexes. On only a part of the papers was age given, but there is reason to believe that vocabularies increase up to thirty. In Pratt Institute where students varied greatly in age, those above twenty-five knew from five to ten per cent. more words than those in the same classes who were below twenty years of age. It is not likely that the growth of vocabulary is great after thirty, when deeper specialized and executive activities have taken the place of general advancement into new fields of knowledge and many words once known are forgotten.

One important factor in the growth of vocabularies was investigated by accompanying the list of words with a request to write names of papers and magazines frequently read and of books read since the beginning of the year. It was found that in general those who named the most books and magazines had the larger vocabularies, regardless of their grade.

The individual differences in size of vocabulary were very great, some ninth grade children falling to the rank of second grade children, while some third or fourth grade children ranked with the average of those in the ninth grade or high school.

Sometimes a very small vocabulary was accounted for by the fact that the child was of foreign parentage and did not hear English at home, but the mere fact of being of foreign parentage was no assurance that the vocabulary would be small.

II

The relation of size of vocabulary to school standing was considered, but owing to the scarcity of data and uncertainty as to its reliability (only a small proportion of the papers were accompanied by the class records or teacher's estimate of ability), no conclusive results were reached. In the grades there was no clear proof of relationship though in one room, where there was reason to think the teacher's estimate had been carefully made, the grading corresponded almost exactly to the size of the vocabularies. In one normal class nearly all of those who had been named by the faculty as belonging to the lower third of the class had small vocabularies. In another class there seemed to be little or no relation between size of vocabulary and estimates of teaching ability. In two colleges, one for women, the other for men, the marks given to the women in English and to men in all subjects were secured for the freshman class and compared with the number of words known. The average number of words known by the men who in general ranked in the various subjects above the average of their class was 5 per cent. greater than for those ranking below the average; while the women who ranked highest in English, averaged nearly 4 per cent. better in vocabularies than those who ranked lowest in English.

In the case of individuals there was often a wide divergence between the marks and the size of the vocabulary. In some instances exceptionally poor definitions indicated a difference in the standard used in marking words as known, but not always. This divergence is not, however, greater than between marks in different subjects, *e. g.*, students have honor marks in some subjects and fail to pass in others.

Is size of vocabulary any indication of attainment or ability? An affirmative answer to this can not readily be proved by experiment, because we have no reliable standard of ability and attainment by which the value of the vocabulary test may be determined. It is well known, however, that persons who do well in one subject often do poorly in others and that success in life after school bears little relation to success in school. It has recently been shown by Dr. Thorndike that entrance examinations bear little relation to college marks.

From the side of experimental psychology, no accurate measure of intellectual ability has been established in spite of many persistent and painstaking researches. The various tests used are found to be special in their character. There are also indications that what are good tests at one age or stage of development may have no significance at another stage. Sensory and motor tests are probably valuable indications of mental ability in young children, memory and imagination tests in older children and reasoning tests in youths.

The function of the nervous system is to respond in an appropriate way to the various phases of the stimulating environment. The most common phase of environment to which human beings respond is the word environment, first to auditory words by movements, then to auditory and visual words by images and concepts. The number of words that are known by any person depends upon two factors, the variety in his word environment, auditory and visual, and his own readiness to respond to the various elements of this environment. It is perfectly natural therefore that children who are surrounded by intellectual people or who read a great deal should have large vocabularies and yet that the size of individual vocabularies should vary with their readiness to respond to this word environment. The accuracy of response or quality of knowledge can be judged not by the number of words but by the accuracy of definitions or use of words.

The question naturally arises whether size of vocabulary and ability to define and use words is not a sufficiently accurate measure of the intellectual ability of youths to justify the use of vocabulary tests in examinations for entrance to college. College work is supposed to be general in its character, demanding general ability, of which the vocabulary test ought to give an indication. Of course if students should devote their time to a special study of the dictionary, the test would become special and valueless, since size of vocabulary would not then be an accompaniment and indication of experiences and intellectual advances, but of special study of modes of defining words in terms of other word symbols.

III

A study of the kind of definitions given by persons of different ages is an interesting indication of the sources of word knowledge and of the modes of thought at different ages.

The first words are of course obtained from direct association with acts and objects and this continues to be a source of vocabulary growth.

A large proportion of words, however, come indirectly from experience through the medium of words that have already become familiar. These new words are sometimes received as equivalents of other words, because of synonyms and definitions or of special descriptions. The greater part of them, however, gain their significance from their association with familiar words in various situations, just as the original words were gained from association with various real situations.

These truths may be illustrated by the definitions of gourd given by college students. 'A drinking cup made from the gourd vine.' 'A vegetable which grows in the ground having a hard shell and many seeds.' 'A vessel for holding water or other liquid.' 'A receptacle for carrying water about, usually of skin.' 'A water bottle made from a pumpkin or squash.' 'Vessel sometimes made by scooping out, for example, making a vessel by scooping out a pumpkin.' Evidently most of these definitions represent ideas gained from sentences in which the word, 'gourd' is used, though those who speak of them as 'pumpkins' or as a 'summer squash,' may have seen the real thing without the discriminating eye of the gardener or botanist. The idea that it is a vessel of some kind evidently predominates and this idea is sufficient for interpreting most sentences in which the word occurs.

It is interesting to notice the various forms of the subordinate idea of the object itself as the various persons picture it under the stimulus of the context. 'A shell of certain nuts, fruits and vegetables, or of the cocoanut, squash, cucumber, etc.' 'In many countries it is used as a receptacle for food and drink.' 'A fruit on a tree whose shell is used for carrying water.' 'The dry fruit of some sort of tropical tree.' 'It is hard and round, and some are the size of an apple and rattle when you shake them.' 'A species of dried melon.' 'An old style wooden drinking vessel.' 'A hollow piece of cane.' 'A fruit characterized by the fibrous outer shell similar to the cocoanut.' Few of the writers of the above had a sufficiently correct idea of the article to be able to identify it if it were shown them. They react satisfactorily (to themselves) to the book situation though they would be laughed at by the gardener and botanist. It is an interesting fact that in a prominent college for women the word 'decemvirate,' which only readers of Roman history would be likely to encounter, was correctly defined by most of the young ladies, while some could give no definition for gourd, and many others gave such definitions as have been quoted. This is a striking illustration of the difference between the word environment of scholastic halls and that of the industries and the literature of to-day.

The following definitions of gourd are inexplicable until one realizes that one word form has been mistaken for another. 'To spur on' (goad). 'To plunge a weapon into some one, to make a jagged wound' (gored). 'An animal' (goat?). 'A greedy person' (gourmand). 'A chasm or piece of land that is very much lower than the surrounding land' (gorge).

The definitions thus far quoted are by college students, and though most of them are exceptional rather than characteristic of the definitions of college students, they are surprising as well as amusing.

One English teacher was so astonished at the 'depth of ignorance' displayed by the definitions of his freshman class in English that he had all the papers looked over by his assistants, who all agreed that the results were 'shocking.' They, however, saw no relation between the definitions and the scholarship of individual pupils. (As has already been stated the figures show that those ranking high in scholarship knew on an average about 5 per cent. more words than those ranking low in scholarship.)

Character of the definitions changed greatly with age. Descriptions which are so common in the high school and college papers are rarely or never given by children in the kindergarten and primary grades. The same is true of definitions by synonyms and inclusions under larger terms. The younger children nearly always define by mention of some specific incident, *e. g.*, 'A *chair* is to sit on'; 'Baby stands up by a *chair*'; 'A *bee* goes around a piazza and makes a noise.' What anything can do, or what can be done to it, or with it, is of most importance in early knowledge of all things, hence we find the definitions of children expressing action and use more than anything else. Reference to personal experience of self and friends is also common. These facts are of great significance to pedagogy, strongly endorsing the change now being made from the old descriptive 'object lesson' to the better forms of nature study in which use is made the center of interest.

MAGICAL MEDICAL PRACTISE IN SOUTH CAROLINA

BY JOHN HAWKINS

AS chemistry began in alchemy and astronomy in astrology, so medicine, to a great extent, has grown out of magic. Its first professors were sorcerers and priests; and its beginnings are to be looked for in the juggleries and mummeries of holy men and women who, by fastings, narcotics, or other means, enabled themselves to communicate with the benignant or malevolent spirits which savage philosophy finds in every object of nature. Among rude peoples the physician is often a priest and always a magician.

Alchemy is dead and astrology as it exists to-day is no longer to be considered seriously by the student of culture; but, owing perhaps to the religious factor in its origin, the science of medicine, as it is understood by a very large number of persons, is still encumbered with the dead husks of its earliest growth. Even in the most enlightened countries physicians are constantly confronted with the idea that disease is a sort of demoniacal possession which is to be relieved by prayer, or that it is some mysterious entity which can be removed only by the use of some equally mysterious remedy. Charms, medals impregnated with virtue by ecclesiastical benediction, and so-called electric and galvanic belts, pads, rings, brushes and other appliances are sold by thousands; and patent panaceas, compounded of drugs brought from strange lands or discovered in some unusual way, are bought and used by millions of credulous and afflicted persons in all parts of the world.

In view of these facts it is not remarkable that one occasionally finds in the United States, as well as in secluded nooks of the Old World, regions in which superstitious medical practises, handed down from father to son for no one knows how many hundreds of years, not only survive, but also show an astonishing degree of vitality.

Such a region occurs in the central part of South Carolina. It is a strip of country about one hundred miles long and from thirty to fifty miles wide, lying along the Santee, the Congaree, Broad and Saluda rivers, and embracing parts of the counties of Orangeburg, Lexington, Newberry and Saluda. The early European settlers of this region were Germans who came, about the middle of the eighteenth century, from the Lower Palatinate, Baden, Würtemberg and Switzerland. At a little later date small groups and isolated families of Scotch-Irish, of English and of French from the Huguenot settlements of the coast region established themselves among these peasants from the banks of the Rhine. But, broadly speaking, this part of Carolina was in the early days a bit of Germany transplanted bodily into the new world; and, undisturbed by subsequent immigration, its inhabitants have retained to the present day many of the traits and characteristics of their ancestors. The existing surnames of the people are still largely German; the Lutheran faith is strong; the language of the fatherland has fallen into disuse almost within the memory of living men; and the customs and superstitions which prevail are, to a great extent, those bequeathed by the pioneers to their descendants.

Until ninety or a hundred years ago, according to local historians, there were no physicians in this region. Besides the stock of medical lore in the possession of the old women of every country neighborhood, the sick had recourse only to a system of practise known as 'using,' which consisted in rubbing the affected part with the hands of the operator, blowing the breath upon it, and repeating over the patient certain ancient charms or incantations, in the efficacy of which both doctor and patient had unbounded faith.

At the present day physicians are here plentiful, and in learning and skill they compare favorably with those of any country district. Many of them have enjoyed the advantages of the best schools in America, and some have studied abroad. Yet here extremes meet, and the highest and the lowest join hands. The skillful modern physician, armed with all the resources of science, sometimes finds himself face to face with a method of medical treatment as old as humanity itself; and he must pit his pills and powders against magical charms, some of which bear on their face the marks of a time when Thor and Woden were realities and not myths in the minds of men.

It must not be understood that 'using' is very generally practised. Its employment is now uncommon and exceptional. As a rule the Teutonic Carolinians are fairly intelligent, having schools, churches and newspapers, and superstition is dying out. But a stubborn conservatism, seemingly innate in human nature, makes such things die hard. There is still a class of people which clings tenaciously to the old beliefs; and this class is apt—especially when regular physicians fail, as they sometimes must, to relieve the afflicted—to have recourse to some old man or woman who enjoys a local reputation for skill in magic. Whether a cure is thus effected or not, belief in the method is not shaken, for, as Bacon remarks, men count the hits but not the misses. An occasional success offsets many failures, and so faith in the formulas which age and the authority of the elders have rendered sacred remains unimpaired.

As one star differeth from another in glory, so, too, the practitioners of 'using' differ from one another in skill and in extent of knowledge. Some are acquainted with the methods, but have little success in practise. To some who are successful only one or two of the charms are known; others possess a half dozen or more. Skillful or unskillful, however, 'users' are by no means numerous, and when emergencies arise that demand their services it is sometimes necessary to send to considerable distances before one is found. Their scarcity is due to the fact that the formulas are jealously guarded, since the promiscuous disclosure of the secrets is thought to take away the possessor's influence over the powers which bring disease and death. The ethics of the profession demand that when an adept at 'using' feels the approach of age and death he shall divulge his magical knowledge to some one (and to one only) who is worthy to possess it; and this one is bound to transmit it in like manner to a single successor.

It is not altogether impossible, however, as this article will show, for one of the uninitiated to obtain possession of the formulas. One may sometimes find a possessor of the mystic charms who is not unwilling to communicate them to another for a money consideration. Of those grouped together below, eight were secured in this way. The remainder, with one exception, were then obtained by a system of exchange, charm being given for charm.

So much by way of preface to the formulas themselves, which are here given in italics, the directions for their use being printed in ordinary type. The authorities are followed *verbatim:*

FOR CATARACT: *I rub you with my right thumb, that you may move and depart. In the name of the Father and of the Son and of the Holy Ghost. Amen.* Rub it with the thumb from the nose outwards until you say the above words, blowing first three times. This must be done three mornings and evenings, every time three times.

FOR A FILM OVER THE EYE: *Eye, I do not know what ails you; I know not whence it is. There shall it go. In the name of the Father, the Son, and the Holy Ghost. Amen.* Rub the eye three times with the right hand and repeat three times.

FOR A BLISTER IN THE EYE: *Joseph begat Anna, Anna begat Mary, Mary begat our Lord and Saviour, Jesus Christ. This is most certainly true. Blotch, blister, go away. Do this man's [woman's] eye no harm. In the name of the Father, Son, and Holy Ghost. Amen.* Say it three times.

FOR A BURN OR SCALD: *O! you hot and burning flame, you are so hot and dark! With God, the Father, I drive you; with God, the Son, go you away. In the name of the Father, Son, and Holy Ghost. Amen.* Blow the breath three times upon the burn, pass the hand thrice over it, and say these words three times.

FOR A BURN OR SCALD: *The Holy Woman goes out over the land; what carries she in her hand? A fire-brand. Eat not in you, eat not around you. In the name of the Father, the Son, and the Holy Ghost. Amen.* Say these words three times, rub three times upward and downward, and blow three times —every time three times.

FOR INFLAMMATION: *St. John came over with all his congregation; St. Mary came over with all her communication; Christ is mighty to cure mortification and all other complaints. In the name of the Father and Son and Holy Ghost. Amen.* Say it three times.

FOR THE LIVER-GROWN: *Liver-grown and Heart-bound depart from thy ribs, as Jesus went out of the manger. In the name of God, the Father, Son, and Holy Ghost. Amen.* Dip your thumbs in fat and rub three times upon the breast and three times upon the back as you say the above words, every morning and evening for three mornings and evenings, three times. This must be done at odd hours—one, three, five, seven, nine or eleven o'clock.

For the Night-brand or Scrofula: *I forewarn you that you shall no longer burn, but be you cold as a dead man's hand. In the name of the Father, the Son, and the Holy Ghost. Amen.* Take the middle finger of your right hand and rub three times around as you say these words. Do this, morning and evening, three times, for three mornings and evenings.

For Fever: *Jesus went over the mountain, and he saw a great fever and he cured it with his hands. In the name of God, the Father; in the name of God, the Son; in the name of God, the Holy Ghost. Amen.* Rub three times, blow three times, and repeat three times.

For Epilepsy, or Falling Sickness: Take a new broom and sweep from three corners of a room. Throw the sweepings over the person who has the sickness, while you say these words: *In God's name, Falling Sickness, you must depart till I these seed do cut.* So do it three times.

For a Worm in the Finger—Whitlow: *As he* [*she*] *went over muddy bogger's branch he* [*she*] *met three worms; one was a white one, one was a black one, and one was a red one. I command this to die, in the name of the Father and of the Son and of the Holy Ghost. Amen.* Say it three times.

For Stopping Blood: Say the name of the person, then: *Holy is the day and holy is the hour wherein happened the wound. In the name of the Father and of the Son and of the Holy Ghost. Amen.* Say the name of him that has the wound first; and if the wound is on the right side lay your left hand thereupon, and if on the left side lay your right hand thereupon. If you know the name of the person you may stop the bleeding though the person be three or four miles away.

For Colic, or Rising of the Mother: Lay your hand on the person's stomach and say three times: *I stand on wood and I see wood. For one glassful of cold red wine. Rising of Mother, or Colic, let this griping alone. A. B. C. May God help you. In the name of God, the Father; in the name of God, the Son; in the name of God, the Holy Ghost. Amen, Amen, and Amen.*

For a Boil, or Imposthume: *The Boil and the Dragon went over the creek. The Dragon drank, the Boil sank. In the name of the Father, Son, and Holy Ghost. Amen.* Lay your right hand upon the boil as you say these words. Do it three times, and the boil will soon decrease.

For the Wild-fire (Erysipelas): *Wild-fire, move away; the tame-fire is over you.* Take a coal of fire or a fire-brand and rub three times around it morning and evening, each time three times, as you say these words. It will soon be better.

For Greedy-worm: *When our Lord and Savior, Jesus Christ, was upon the earth he met a greedy-worm, and he said, 'Where are you going, greedy-worm? In the child's stomach or no? You shall not do that. That I forbid you, by sulphur and pitch, that I may never see you any more. Do you go in the green wood. There is a well deep and cold. Out of that well you may drink, and of this child nevermore think.' In the name of the Father, in the name of the Son, and in the name of the Holy Ghost. Amen, Amen, and Amen.* Blow your breath three times on the face and say these words three times over.

For Open Head: *Head, I squeeze you together for* [*name of patient*]. *In the name of the Father, Son, and Holy Ghost.* Press together three times each way and say these words three times.

A Cure for Bots:

There was a man
Rode over the land
With three worms in his hand.
One was white, another black, the other red,
And in an hour they were dead.

Stand the horse with his head toward sunrise. Take your right hand and rub from the nose over the head, neck, and back, down to the end of the tail, as you say these words. Do this three times in two or three hours, every time three times. Give some purgative medicine.

There are two more formulas which, though not strictly medical in character, are so nearly akin to those already given that they may be appropriately included in the same list. One of them is used when the first collar is placed upon a colt's neck, and it is supposed to prevent the equine vice known as 'balking,' and to cause the animal to work satisfactorily. It is as follows:

Refuse not to pull while the Jews keep Saturday for Sunday. In the name of the Father, the Son, and the Holy Ghost. Amen.

The other is used to prevent the depredations of thieves and burglars and the approach of deadly enemies. If one has a house or a field which he wishes to protect he should walk around it three times, repeating the incantation each time. It is thought that any one attempting to cross the line thus made will be paralyzed, in his tracks, and will have to stand there until released by the sorcerer. This must be done before sunrise; otherwise the offender may die. The charm is as follows:

When Mary lay in child-bed and Joseph was about to flee away, Joseph cried out and said: 'There goes a thief in our house who wants to steal the child.' And Mary said: 'St. Peter bade, St. Peter said, "I have bound him in God's hand." Whosoever would, in twenty-three hours, steal from me or do any hurt to my life shall stand there till I tell him to go away.' In the name of the Father, the Son, and the Holy Ghost. Amen.

About seventy years ago the writer's grandfather removed his family from South Carolina to the west, and on the eve of his departure a neighbor gave him this charm for the protection of the wagon-camp at night, but its virtue was never tested. In South Carolina it seems still to be used, and there are two or three recent stories of watermelon thieves having been caught in this way. One relates that at daybreak the thief was seen standing, unable to move or even to drop the bag of stolen melons on his shoulder.

There are also formulas for the cure of cancer and for the removal of warts, but these the writer has not been fortunate enough to secure. A very old lady of his acquaintance, Mrs. R—, from whom some of the formulas mentioned were obtained, says that she was cured of cancer many years ago by one Adam Boland, of Newberry County, who was a famous 'user' in his day. In her case the 'using' was done when she was not present. She says that Boland, after repeating the charm and the name of the patient three times, always took an axe and cut into the heart of a pine tree in order to ascertain whether the treatment would prove successful. If the tree lived the patient would recover; otherwise, the charm was powerless. Mrs. R— gives some further particulars of interest. Her daughter learned a few of the formulas when a child and used them frequently and successfully to relieve her father's illness, although he had no faith in the practise. The charms lose their force if taught by a younger person to an older one; the learner should always be younger than the teacher. The point of view from which many persons look on these superstitious methods of treatment is well illustrated by a remark of Mrs. R—. She says:

I don't see why 'using' shouldn't be as efficient as prayer, since the three highest names [Father, Son, and Holy Ghost] are always used. At any rate it can do no harm, if it does no good; and in this respect it differs from the drugs used by physicians.

If we look for practises analogous to these mentioned here the abundance of material is found to be overwhelming. The use of charms and incantations for the cure of disease may be noted in all ages since the dawn of history and among peoples of all grades of culture. Pepys gives several, current in his day, which are very similar in character to those given above; for example, the following, for stopping blood:

Sanguis mane in te
Sicut Christus fuit in se;
Sanguis mane in tua vena
Sicut Christus in sua pœna;
Sanguis mane fixus
Sicut Christus quando fuit crucifixus.

He also gives one for a burn which is almost identical with one of those now in use in South Carolina:

There came three angels out of the East;
The one brought fire, the other brought frost.
Out, fire; in, frost.
In the name of the Father, Son, and
Holy Ghost. Amen.

Reginald Scot in 'The Discoverie of Witchcraft,' published in 1584, records an accredited method:

To heale the King's or Queen's evill, or any other sorenesse of the throte: Let a virgine, fasting, laie hir hand on the sore and saie: *Apollo denieth that the heate of the plague can increase where a naked virgine quencheth it, and spet three times upon it.*

This is interesting as showing the survival of a formula dating from pre-Christian times. There is very good reason for believing that the incantations of the 'users' of the present day may claim an equal antiquity. Like some of the festivals of the church, they had their origin in heathen times, and the introduction of Christianity did not suffice to shake their hold on the popular mind. In old Germany neither Charlemagne's conquest nor the priest who followed it could put a period to the use of staves carved with mystic runes and devoted to the purposes of divination and incantation. The oak, the ash and the willow preserved their sacred character; and in the old heathen formulas for the cure of disease, the only change effected by Christianity was the substitution of the 'three highest names' (Father, Son and Holy Ghost) for those of Thor, Woden and other heathen deities. The following heathen and Christian versions of a popular charm for sprains will illustrate the change effected:

Old Version.

Phol and Woden
went to the wood;
there was of Balder's colt
his foot wrenched;

then Sinthgunt charmed it,
and Sunna her sister;
then Frua charmed it,
and Volla her sister;
then Woden charmed it,
as he well could,
as well the bone-wrench,
as the joint-wrench,
as the blood-wrench;
bone to bone,
blood to blood,
joint to joint,
as if they were glued together.

CHRISTIANIZED VERSION.

Our Lord rade,
His foal's foot slade;
Down he lighted,
His foal's foot righted;
Bone to bone,
Sinew to sinew,
Flesh to flesh.
Heal, in the name of the Father,
the Son, and the Holy Ghost. Amen.

Examples of similar formulas might be multiplied indefinitely from all parts of the world, and from the remotest times to the present, but this is unnecessary. It is enough to note the curious fact that if the practise of the Carolina 'users' of the present day could be witnessed by Egyptian physicians of four thousand years ago, by Druid priests from the Gaul described by Cæsar, and by American Indian medicine men from the time of Columbus, it would appear to all of them a perfectly natural and philosophical method of treatment, however unintelligible the language of the formulas might be.

Besides the superstitions already cited, there exists in this region a number of other magical healing practises. These, however, unlike 'using,' can not be said to belong exclusively to that part of the population which is descended from the early German settlers. Africa is certainly the native land of some of them. The others form a part of that vast body of popular lore, of mixed and uncertain origin, which is the common property of the people of northern and western Europe and their descendants.

A prescription for rheumatism is closely allied to some of the 'using' practises, although no words are to be repeated over the patient. It is compounded of a teacupful of sweet cream, thickened with salt, seven buds of brier, nine of rosemary and eleven grains of black pepper. When these have been allowed to simmer together the mixture is to be skimmed, and with the remaining ointment the rheumatic parts are to be rubbed 'downward and outward on three Fridays in the dark of the moon.' Simpler remedies for rheumatism are rattle-snake oil; grease fried from toads; and a sharp knife or razor taken to bed with the patient to 'cut the pains.'

To cure cramp it is only necessary to wear garters of eel-skin, or to invert the sufferer's shoes under his bed at night. Herpes, or shingles, should be rubbed with blood from a black cat's tail or from a black fowl's neck. Treatment should be prompt, as it is thought that the patient will certainly die if the inflammation completely encircles the body.

Negroes seem especially subject to inflammation of the uvula, an ailment known among them as 'falling palate.' In Orangeburg County the favorite treatment consists in pressing the uvula upward with the back of a silver spoon, at the same time pulling strongly at a tuft of hair on the top of the head. Many negroes cultivate a tuft of hair, for this purpose, over the middle of the forehead. In another mode of treatment the uvula is supposed to be driven up into its proper place by smart blows administered with a stick upon the soles of the feet.

Warts and corns are everywhere the object of many superstitious practises. In South Carolina the owner of these excrescences may take his choice of several remedies. He may select a broom straw having as many joints as there are warts to be removed, pick the warts until they bleed, and put a drop of blood from each wart upon a joint of the culm, then bury the straw under the eaves of the house. Or he may count the warts and tie in a string the same number of knots, and bury the string. Another method is to rub each wart with a pea, and bury the peas in the same way. Still another is as follows: Tie as many knots in a string as there are warts to be removed; blindfold the patient and lead him about until he is lost; then give him the string, which he should bury in the ground, unobserved by any one. As the string decays the warts will disappear. Corns may be removed by rubbing them with a grain of corn and then feeding the grain to the oldest fowl in the yard. This last remedy comes from a very old negro woman, still living, who was brought from Africa in her childhood; but this may not mean that the remedy is African in origin.

An old lady, whose parents were Scotch-Irish, gives the following remedy for bleeding of the nose: Let the nose bleed on three pieces of cloth, put these in three holes bored into as many different kinds of fruit-bearing trees, and stop the holes. This will result in a permanent cure. A gruesome drink for epilepsy is a tea made of a piece of rope with which some one has been hanged. Equally repulsive is a reputed remedy for chills and fever, consisting of pills made of dried and pulverized earthworms. Risings and boils may be cured by the touch of one who has crushed a ground-mole to death in his hands.

Either from the great number of ailments to which they are subject or from their helplessness, or possibly from both causes combined, infants claim a large share of magical medical practise. When a baby is born an axe is sometimes placed under the mother's couch with the blade upward to cut the 'after-pains' of childbirth. To render teething easy and painless the infant's gums are rubbed with a 'cooter' bone, the ear or bone of a rabbit, or the warm brains of the same animal just killed. It is thought that nine live wood-lice tied in a bag and suspended from the neck of a child having thrush will soon give relief. The touch of a posthumous son is recommended for the same complaint. As a preventive of croup a black silk thread or a string of 'electric' (amber) beads is placed around the neck.

In the little city of Newberry a few years ago an infant was supposed to have been cured of a disease known as 'stretches' by passing it through a horse-collar warm from use. Some authorities say that shoe-sole tea should first be administered, to be followed by the horse-collar treatment. In the same county an infant who had a case of umbilical hernia was passed by his father through a cleft in a living young white-oak tree. The theory was that the child would recover if the tree lived; if it died the hernia would remain. The tree and the patient, both of them living and whole, are still here to convince unbelievers of the virtues of magical medicine.

The passing of children through rings of various kinds is comparatively common. One of the 'using' formulas already given in this article is for the cure of 'liver-grown,' an ailment known also as 'growed-on' and 'grow-fast,' in which the liver is supposed to adhere abnormally to some other organ. This is also treated by passing the patient through a horse-collar or between the rungs of a ladder. In still another method the afflicted infant is passed between the legs of a table, after which it is held by the feet and tossed upwards towards each of the four corners of the room, care being taken, however, to prevent it from falling or from striking the walls. In Newberry County, several years ago, a negro mother, misunderstanding the directions given her by an old woman for this treatment, killed her child by throwing it forcibly against the four corners of her log house.

It is not always easy to explain the philosophy of superstition, but in these cases the thought underlying the treatment is sufficiently evident. The idea seems to be that disease is caused by an evil spirit which may be misled and puzzled by mazes of rings and tortuous passages. Thus, interlaced cords are still sold in Italy as charms, and Persian carpets are woven in intricate patterns to bewilder the evil eye.

Analogies to the Carolina practises cited are abundant and they lead us back to very remote times. Mr. Edward Clodd, the English author of several works on custom, myth and religion, is authority for the statement that the practise of drawing infants through the cleft trunks of trees (usually ash) still prevails in remote rural districts of England. Scotch witches in effecting magical cures used to pass their patients nine times through rings or garlands of woodbine; and from

Scotland comes also the custom of passing young chicks through the orbits of a horse's skull to keep the hawks from catching them. The perforated monoliths of Great Britain and northern Europe are known generally as 'Odin Stones,' probably because, according to the Norse mythology, Odin in the shape of a worm bored his head through a stone to get at the 'mead of poetry'; and babies have been drawn through them from ancient times to cure them of various ailments. These monoliths, as well as the small perforated 'Odin' stones still used as amulets in the same countries, are closely related to the salagrama, or holy stone, common, curiously enough, to Italy and India. In Italy the salagrama is a stalagmite which is believed, on account of its resemblance to the mounds thrown up by earthworms, to be such a mound petrified. The people carry it in a bag with some magical herbs, and repeat over it an incantation which recites that its cavities and irregularities are potent to bewilder the evil eye. The Indian salagrama is a kind of ammonite about as large as an orange and having a hole through it. A legend relates that Vishnu, the Preserver, when pursued by the Destroyer, was changed by Maya into the stone, through which as a worm the Destroyer bored his way. It is believed that the evil eye is blunted by the perforation and by the irregularities of the stone's surface.

The survival in the midst of a high civilization of these Carolina practises, allied as they are to practises and beliefs of almost primitive times, affords a pertinent illustration of the manner in which magical arts cling to life. We have seen how heathen charms and incantations not only failed to disappear before the coming of Christianity, but even gained a new lease of life by hastening to enlist themselves under its banner. It is the same way with superstitions in general. Adapting themselves from age to age to the changed conditions which surround them, here receding and there advancing, dying out only to reappear under changed and scarcely recognizable forms, they yield almost imperceptibly to the advance of sound learning and common sense. Their retreat, however, has been more rapid since science has begun to shed her rays into the dark places where such things hide themselves; and in proportion as this great light becomes more generally diffused magic in medicine, as in all other departments of human thought, will fade and finally disappear.

THE VALUE OF SCIENCE

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CHAPTER V. ANALYSIS AND PHYSICS

I

YOU have doubtless often been asked of what good are mathematics and whether these delicate constructions entirely mind-made are not artificial and born of our caprice.

Among those who put this question I should make a distinction; practical people ask of us only the means of money-making. These merit no reply; rather would it be proper to ask of them what is the good of accumulating so much wealth and whether, to get time to acquire it, art and science are to be neglected, which alone should make us capable of enjoying it, 'and for life's sake to sacrifice all reasons for living.'

Besides, a science made solely in view of applications is impossible; truths are fecund only if bound together. If we devote ourselves solely to those truths whence we expect an immediate result, the intermediary links are wanting and there will no longer be a chain.

The men most disdainful of theory get from it, without suspecting it, their daily bread; deprived of this food, progress would quickly cease, and we should soon congeal into the immobility of China.

But enough of uncompromising practicians! Besides these, there are those who are only interested in nature and who ask us if we can enable them to know it better.

To answer these, we have only to show them the two monuments already rough-hewn, Celestial Mechanics and Mathematical Physics.

They would doubtless concede that these structures are well worth the trouble they have cost us. But this is not enough. Mathematics have a triple aim. They must furnish an instrument for the study of nature. But that is not all: they have a philosophic aim and, I dare maintain, an esthetic aim. They must aid the philosopher to fathom the notions of number, of space, of time. And above all their adepts find therein delights analogous to those given by painting and music. They admire the delicate harmony of numbers and forms; they marvel when a new discovery opens to them an unexpected perspective; and has not the joy they thus feel the esthetic character, even though the senses take no part therein? Only a privileged few are called to enjoy it fully, it is true, but is not this the case for all the noblest arts?

This is why I do not hesitate to say that mathematics deserve to be cultivated for their own sake, and that the theories inapplicable to physics should be so as well as the others. Even if the physical aim and the esthetic aim were not united, we ought not to sacrifice either.

But more: these two aims are inseparable and the best means of attaining one is to aim at the other, or at least never to lose sight of it. This is what I am about to try to demonstrate in setting forth the nature of the relations between the pure science and its applications.

The mathematician should not be for the physicist a mere purveyor of formulas; there should be between them a more intimate collaboration. Mathematical physics and pure analysis are not merely adjacent powers, maintaining good neighborly relations; they mutually interpenetrate and their spirit is the same. This will be better understood when I have shown what physics gets from mathematics and what mathematics, in return, borrows from physics.

II

The physicist can not ask of the analyst to reveal to him a new truth; the latter could at most only aid him to foresee it. It is a long time since one still dreamt of forestalling experiment, or of constructing the entire world on certain premature hypotheses. Since all those constructions in which one yet took a naive delight it is an age, to-day only their ruins remain.

All laws are therefore deduced from experiment; but to enunciate them, a special language is needful; ordinary language is too poor, it is besides too vague, to express relations so delicate, so rich, and so precise.

This therefore is one reason why the physicist can not do without mathematics; it furnishes him the only language he can speak. And a well-made language is no indifferent thing; not to go beyond physics, the unknown man who invented the word *heat* devoted many generations to error. Heat has been treated as a substance, simply because it was designated by a substantive, and it has been thought indestructible.

On the other hand, he who invented the word *electricity* had the unmerited good fortune to implicitly endow physics with a *new* law, that of the conservation of electricity, which, by a pure chance, has been found exact, at least until now.

Well, to continue the simile, the writers who embellish a language, who treat it as an object of art, make of it at the same time a more supple instrument, more apt for rendering shades of thought.

We understand, then, how the analyst, who pursues a purely esthetic aim, helps create, just by that, a language more fit to satisfy the physicist.

But this is not all: law springs from experiment, but not immediately. Experiment is individual, the law deduced from it is general; experiment is only approximate, the law is precise, or at least pretends to be. Experiment is made under conditions always complex, the enunciation of the law eliminates these complications. This is what is called 'correcting the systematic errors.'

In a word, to get the law from experiment, it is necessary to generalize; this is a necessity imposed upon the most circumspect observer. But how generalize? Every particular truth may evidently be extended in an infinity of ways. Among these thousand routes opening before us, it is necessary to make a choice, at least provisional; in this choice, what shall guide us?

It can only be analogy. But how vague is this word! Primitive man knew only crude analogies, those which strike the senses, those of colors or of sounds. He never would have dreamt of likening light to radiant heat.

What has taught us to know the true, profound analogies, those the eyes do not see but reason divines?

It is the mathematical spirit, which disdains matter to cling only to pure form. This it is which has taught us to give the same name to things differing only in material, to call by the same name, for instance, the multiplication of quaternions and that of whole numbers.

If quaternions, of which I have just spoken, had not been so promptly utilized by the English physicists, many persons would doubtless see in them only a useless fancy, and yet, in teaching us to liken what appearances separate, they would have already rendered us more apt to penetrate the secrets of nature.

Such are the services the physicist should expect of analysis; but for this science to be able to render them, it must be cultivated in the broadest fashion without immediate expectation of utility—the mathematician must have worked as artist.

What we ask of him is to help us to see, to discern our way in the labyrinth which opens before us. Now, he sees best who stands highest. Examples abound, and I limit myself to the most striking.

The first will show us how to change the language suffices to reveal generalizations not before suspected.

When Newton's law has been substituted for Kepler's, we still know only elliptic motion. Now, in so far as concerns this motion, the two laws differ only in form; we pass from one to the other by a simple differentiation. And yet from Newton's law may be deduced by an immediate generalization all the effects of perturbations and the whole of celestial mechanics. If, on the other hand, Kepler's enunciation had been retained, no one would ever have regarded the orbits of the perturbed plants, those complicated curves of which no one has ever written the equation, as the natural generalizations of the ellipse. The progress of observations would only have served to create belief in chaos.

The second example is equally deserving of consideration.

When Maxwell began his work, the laws of electro-dynamics admitted up to his time accounted for all the known facts. It was not a new experiment which came to invalidate them. But in looking at them under a new bias, Maxwell saw that the equations became more symmetrical when a term was added, and besides, this term was too small to produce effects appreciable with the old methods.

You know that Maxwell's *a priori* views awaited for twenty years an experimental confirmation; or if you prefer, Maxwell was twenty years ahead of experiment. How was this triumph obtained?

It was because Maxwell was profoundly steeped in the sense of mathematical symmetry; would he have been so, if others before him had not studied this symmetry for its own beauty?

It was because Maxwell was accustomed to 'think in vectors,' and yet it was through the theory of imaginaries (neomonics) that vectors were introduced into analysis. And those who invented imaginaries hardly suspected the advantage which would be obtained from them for the study of the real world; of this the name given them is proof sufficient.

In a word, Maxwell was perhaps not an able analyst, but this ability would have been for him only a useless and bothersome baggage. On the other hand, he had in the highest degree the intimate sense of mathematical analogies. Therefore it is that he made good mathematical physics.

Maxwell's example teaches us still another thing.

How should the equations of mathematical physics be treated? Should we simply deduce all the consequences, and regard them as intangible realities? Far from it; what they should teach us above all is what can and what should be changed. It is thus that we get from them something useful.

The third example goes to show us how we may perceive mathematical analogies between phenomena which have physically no relation either apparent or real, so that the laws of one of these phenomena aid us to divine those of the other.

The very same equation, that of Laplace, is met in the theory of Newtonian attraction, in that of the motion of liquids, in that of the electric potential, in that of magnetism, in that of the propagation of heat and in still many others. What is the result? These theories seem images copied one from the other; they are mutually illuminating, borrowing their language from each other; ask electricians if they do not felicitate themselves on having invented the phrase flow of force, suggested by hydrodynamics and the theory of heat.

Thus mathematical analogies not only may make us foresee physical analogies, but besides do not cease to be useful when these latter fail.

To sum up, the aim of mathematical physics is not only to facilitate for the physicist the numerical calculation of certain constants or the integration of certain differential equations. It is besides, it is above all, to reveal to him the hidden harmony of things in making him see them in a new way.

Of all the parts of analysis, the most elevated, the purest, so to speak, will be the most fruitful in the hands of those who know how to use them.

III

Let us now see what analysis owes to physics.

It would be necessary to have completely forgotten the history of science not to remember that the desire to understand nature has had on the development of mathematics the most constant and happiest influence.

In the first place the physicist sets us problems whose solution he expects of us. But in proposing them to us, he has largely paid us in advance for the service we shall render him, if we solve them.

If I may be allowed to continue my comparison with the fine arts, the pure mathematician who should forget the existence of the exterior world would be like a painter who knew how to harmoniously combine colors and forms, but who lacked models. His creative power would soon be exhausted.

The combinations which numbers and symbols may form are an infinite multitude. In this multitude how shall we choose those which are worthy to fix our attention? Shall we let ourselves be guided solely by our caprice? This caprice, which itself would besides soon tire, would doubtless carry us very far apart and we should quickly cease to understand each other.

But this is only the smaller side of the question. Physics will doubtless prevent our straying, but it will also preserve us from a danger much more formidable; it will prevent our ceaselessly going around in the same circle.

History proves that physics has not only forced us to choose among problems which came in a crowd; it has imposed upon us such as we should without it never have dreamed of. However varied may be the imagination of man, nature is still a thousand times richer. To follow her we must take ways we have neglected, and these paths lead us often to summits whence we discover new countries. What could be more useful!

It is with mathematical symbols as with physical realities; it is in comparing the different aspects of things that we are able to comprehend their inner harmony, which alone is beautiful and consequently worthy of our efforts.

The first example I shall cite is so old we are tempted to forget it; it is nevertheless the most important of all.

The sole natural object of mathematical thought is the whole number. It is the external world which has imposed the continuum upon us, which we doubtless have invented, but which it has forced us to invent. Without it there would be no infinitesimal analysis; all mathematical science would reduce itself to arithmetic or to the theory of substitutions.

On the contrary, we have devoted to the study of the continuum almost all our time and all our strength. Who will regret it; who will think that this time and this strength have been wasted? Analysis unfolds before us infinite perspectives that arithmetic never suspects; it shows us at a glance a majestic assemblage whose array is simple and symmetric; on the contrary, in the theory of numbers, where reigns the unforeseen, the view is, so to speak, arrested at every step.

Doubtless it will be said that outside of the whole number there is no rigor, and consequently no mathematical truth; that the whole number hides everywhere, and that we must strive to render transparent the screens which cloak it, even if to do so we must resign ourselves to interminable repetitions. Let us not be such purists and let us be grateful to the continuum, which, if *all* springs from the whole number, was alone capable of making *so much* proceed therefrom.

Need I also recall that M. Hermite obtained a surprising advantage from the introduction of continuous variables into the theory of numbers? Thus the whole number's own domain is itself invaded, and this invasion has established order where disorder reigned.

See what we owe to the continuum and consequently to physical nature.

Fourier's series is a precious instrument of which analysis makes continual use, it is by this means that it has been able to represent discontinuous functions; Fourier invented it to solve a problem of physics relative to the propagation of heat. If this problem had not come up naturally, we should never have dared to give discontinuity its rights; we should still long have regarded continuous functions as the only true functions.

The notion of function has been thereby considerably extended and has received from some logician-analysts an unforeseen development. These analysts have thus adventured into regions where reigns the purest abstraction and have gone as far away as possible from the real world. Yet it is a problem of physics which has furnished them the occasion.

After Fourier's series, other analogous series have entered the domain of analysis; they have entered by the same door; they have been imagined in view of applications.

The theory of partial differential equations of the second order has an analogous history. It has been developed chiefly by and for physics. But it may take many forms, because such an equation does not suffice to determine the unknown function, it is necessary to adjoin to it complementary conditions which are called conditions at the limits; whence many different problems.

If the analysts had abandoned themselves to their natural tendencies, they would never have known but one, that which Madame Kovalevski has treated in her celebrated memoir. But there are a multitude of others which they would have ignored. Each of the theories of physics, that of electricity, that of heat, presents us these equations under a new aspect. It may therefore be said that without these theories we should not know partial differential equations.

It is needless to multiply examples. I have given enough to be able to conclude: when physicists ask of us the solution of a problem, it is not a duty-service they impose upon us, it is on the contrary we who owe them thanks.

IV

But this is not all; physics not only gives us the occasion to solve problems; it aids us to find the means thereto, and that in two ways. It makes us foresee the solution; it suggests arguments to us.

I have spoken above of Laplace's equation which is met in a multitude of diverse physical theories. It is found again in geometry, in the theory of conformal representation and in pure analysis, in that of imaginaries.

In this way, in the study of functions of complex variables, the analyst, alongside of the geometric image, which is his usual instrument, finds many physical images which he may make use of with the same success. Thanks to these images he can see at a glance what pure deduction would show him only successively. He masses thus the separate elements of the solution, and by a sort of intuition divines before being able to demonstrate.

To divine before demonstrating! Need I recall that thus have been made all the important discoveries? How many are the truths that physical analogies permit us to present and that we are not in condition to establish by rigorous reasoning!

For example, mathematical physics introduces a great number of developments in series. No one doubts that these developments converge; but the mathematical certitude is lacking. These are so many conquests assured for the investigators who shall come after us.

On the other hand, physics furnishes us not alone solutions; it furnishes us besides, in a certain measure, arguments. It will suffice to recall how Felix Klein, in a question relative to Riemann surfaces, has had recourse to the properties of electric currents.

It is true, the arguments of this species are not rigorous, in the sense the analyst attaches to this word. And here a question arises: How can a demonstration not sufficiently rigorous for the analyst suffice for the physicist? It seems there can not be two rigors, that rigor is or is not, and that, where it is not there can not be deduction.

This apparent paradox will be better understood by recalling under what conditions number is applied to natural phenomena. Whence come in general the difficulties encountered in seeking rigor? We strike them almost always in seeking to establish that some quantity tends to some limit, or that some function is continuous, or that it has a derivative.

Now the numbers the physicist measures by experiment are never known except approximately; and besides, any function always differs as little as you choose from a discontinuous function, and at the same time it differs as little as you choose from a continuous function. The physicist may, therefore, at will suppose that the function studied is continuous, or that it is discontinuous; that it has or has not a derivative; and may do so without fear of ever being contradicted, either by present experience or by any future experiment. We see that with such liberty he makes sport of difficulties which stop the analyst. He may always reason as if all the functions which occur in his calculations were entire polynomials.

Thus the sketch which suffices for physics is not the deduction which analysis requires. It does not follow thence that one can not aid in finding the other. So many physical sketches have already been transformed into rigorous demonstrations that to-day this transformation is easy. There would be plenty of examples did I not fear in citing them to tire the reader.

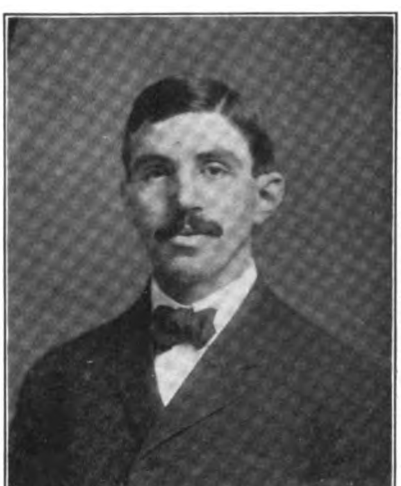
I hope I have said enough to show that pure analysis and mathematical physics may serve one another without making any sacrifice one to the other, and that each of these two sciences should rejoice in all which elevates its associate.

THE PROGRESS OF SCIENCE

THE CONVOCATION WEEK MEETINGS

The meetings of the American Association for the Advancement of Science and of the twenty-one national scientific societies affiliated with it, held in New York City from December 26 to January 2, exhibited convincingly the great progress that has taken place in this country in scientific research and in scientific organization. Twenty years ago Brown Goode, who was better informed than any other in regard to the history of science in America, estimated that our scientific men numbered about five hundred. There were about 2,500 scientific men at the New York meeting and about 800 scientific papers were presented before the sections of the association and the special societies. The growth of our scientific institutions and the increase in the number of our scientific men appear to be in a geometric ratio. There are now at least 5,000 scientific men in the United States, and it is by no means impossible that twenty years hence the number will be 50,000. And this is but as it should be. There are 100,000 physicians and 500,000 teachers in the country, and one half of the physicians and one tenth of the teachers might to advantage engage in scientific research. The nation can certainly afford to devote one tenth of its resources and one tenth of its people to ideal ends, and in the case of science the conditions are favorable also on the economic side, for the more we give to science the more we receive from it.

It seems almost impossible to select from the hundreds of scientific addresses, papers and discussions any for special mention. Some people are disappointed because no great discovery is announced at such a meeting. As a



Edward Kasner, Professor of Mathematics in Columbia University, Vice-president for the Section of Mathematics and Astronomy.

Clifford Richardson, Director of the New York Testing Laboratories, Vice-president for the Section of Chemistry.

Jessie Tarbox Beals, photographer.

WELD. FISHER. LANE. HOBBS. MCNAIR. WARD.
BENJAMIN. HOWARD. R. S. WOODWARD. SUMMERS. CONKLIN. OSBORN.
TRELEASE. MCGEE. RICE. C. M. WOODWARD. WELCH. CATTELL. HAZEN. MACDOUGAL. HAYFORD.

SOME MEMBERS OF THE COUNCIL OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

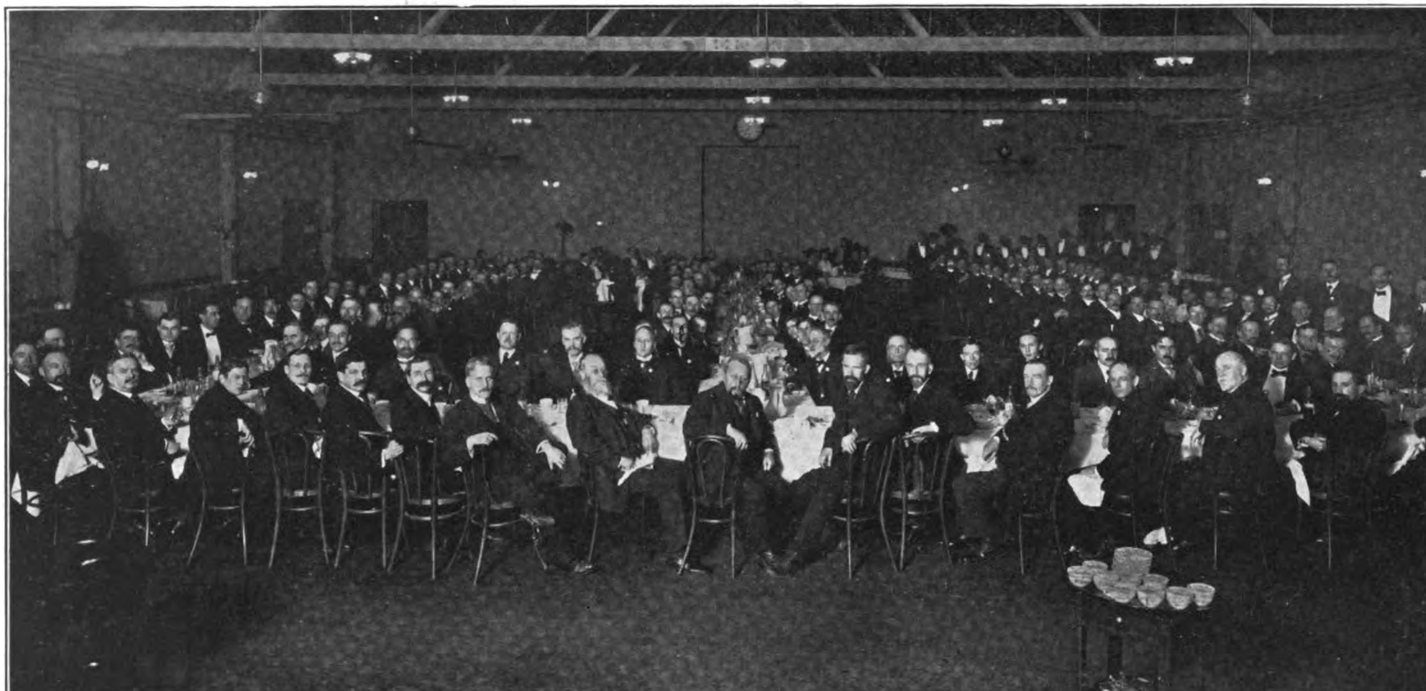
Alfred C. Lane, State Geologist of Michigan, Vice-president for the Section of Geology and Geography.

matter of fact, the great discoveries in the history of science are but few, and it is as a rule only in retrospect that they are seen in their true perspective. The doctrine of the origin of species by natural selection is probably one of the two great scientific advances of the past century, and it was clearly and dramatically announced at a certain meeting of the Linnean Society. Yet no one would expect the newspapers the next morning to devote their front pages to a report of the meeting. The work of the scientific men of the country during the year was more important for the people than the proceedings of its congress and legislatures, and this work was in large measure reported at the New York meeting. Almost any one of the researches presented might be the subject of an interesting article; abstracts of all of them, so brief as to be unintelligible, would fill a volume of the Monthly.

The first article of the constitution of the American Association reads as follows: "The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness." Certainly a meeting such as that of the present year does much to advance these objects. The council of the association, to which the affiliated societies now elect delegates, is a body truly representative of scientific research and of scientific men. Its functions in the future will probably become more important than hitherto, for it is not only able to conduct the business of the association, but to exert a predominant influence on the conditions which affect scientific progress.

The retiring president of the Association, Professor Calvin M. Woodward, known both as an engineer and for his

Edwin G. Conklin, Professor of Zoology in the University of Pennsylvania, Vice-president for the Section of Zoology.



Jessie Tarbox Beals, photographer.

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DINNER OF THE AMERICAN SOCIETY OF NATURALISTS.

1. Dr. Charles B. Davenport, President of the Society. 2. Professor J. Playfair McMurrich, president-elect. 3. Professor D. P. Penhallow, vice-president. 4. Professor E. L. Thorndike, secretary. 5. Dr. William H. Welch, president of the American Association. 6. Dr. L. O. Howard, secretary of the Association.

W. R. WARNER, President of the Warner and Swasey Company, Vice-president of the Section for Mechanical Science and Engineering.

leadership in introducing manual training in the schools, chose as the subject of his address 'The Science of Education,' and one of the most important transactions of the association was the establishment of a section of education. A similar section of the British Association, established several

CHARLES A. CONANT, Treasurer of the Morton Trust Company, Vice president for the Section for Social and Economic Science.

years ago, has proved to be of much value, and there is reason to believe that this section, which begins auspiciously with Dr. Elmer E. Brown, U. S. commissioner of education, as chairman, will accomplish much for the advancement of education as a science, for the teaching of science in the schools and colleges and for the improvement of educational administration in our schools, colleges and universities.

The section last established was one for physiology and experimental medicine, which at the present meeting

SIMON FLEXNER, Director of the Laboratories of the Rockefeller Institute for Medical Research, Vice-president for the Section of Physiology and Experimental Medicine.

cooperated with the national societies devoted to physiology, anatomy, bacteriology and psychology, and held a special session for the discussion of 'Protozoa as Factors in the Diseases of Animals and Plants.' It is also noteworthy that for the first time, at least in recent years, a representative of the medical sciences was president of the association, thus giving recognition to the fact that medicine has now taken its place among the sciences. To this result perhaps no one in this country has contributed so much as Dr. W. H. Welch, of the Johns Hopkins University, who presided over the New York meeting. He is succeeded in the presidency by Dr. E. L. Nichols, of Cornell University, who is eminent for his contributions to experimental physics and has at the same time exerted a great influence on educational development and scientific organization. The standard set by the presidency of the association is well maintained by the vice-presidents for the sections, who are as follows: Mathematics and Astronomy. Professor E. O. Lovett, Princeton University; Physics, Professor Dayton C. Miller, Case School of Applied Science; Chemistry, Professor H. P. Talbot, Massachusetts Institute of Technology; Mechanical Science and Engineering, Professor Olin H. Landreth, Union College; Geology and Geography, Professor J. P. Iddings, University of Chicago; Zoology, Professor E. B. Wilson, Columbia University; Botany, Professor C. E. Bessey, University of Nebraska; Anthropology, Professor Franz Boas, Columbia University; Economics and Social Science, Dr. John Franklin Crowell, New York City; Physiology and Experimental Medicine, Dr. Ludvig Hektoen, University of Chicago; Education, Dr. Elmer E. Brown, U. S. Commissioner of Education. The meeting next year will be held at Chicago, where, as throughout Illinois and the adjacent states, science has in recent years begun to rival the earlier development on the Atlantic seaboard.

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING

The first report of the president to the trustees of the Carnegie Foundation gives Mr. Carnegie's original letter, the certificate of incorporation in New York, the act of incorporation by the congress, the by-laws of the corporation, the report of the treasurer, and the rules for granting retiring allowances, as well as an account of what has been accomplished and a discussion of policy by President Pritchett. As has already been announced, the pensions are of two kinds, one given at or after the age of sixty-five to men who have been professors for fifteen years, and one given after twenty-five years of service. The pensions are relatively larger for those having small salaries, being arranged on a sliding scale of from nine tenths to one half the salary. The foundation may give a pension to the widow of a professor entitled to a retiring allowance, and has given pensions to disabled professors, though there is no clear provision covering the latter case.

There are certain accepted institutions, at present fifty-two in number, whose professors receive the pensions automatically on application from the institution, and the foundation may award pensions to professors of other institutions. On October 1, there had been awarded forty-five allowances to professors in accepted institutions, thirty-five allowances to individual professors and eight allowances to widows. The average allowance to the first class is $1,552; to the second $1,302, and to the third $833. Denominational institutions are excluded by the act of incorporation; the inclusion of institutions supported by the state is under advisement.

The report gives the accompanying summary of the salaries of the professors in American colleges. There is also included a history of the pensions of professors and a discussion of standards of admission to universities and colleges.

Mr. Carnegie's great benefaction will aid our universities, colleges and technical schools, and will thus of course be welcomed by their professors. Whether it will, as President Butler of Columbia University says in his annual report, 'lift one of the heaviest

Class of Institutions.	No. of Institutions.	Total No. Professors.	Total Amount Salaries.	Average No. in Faculty.	Average Pay-roll in Institution.	Average Pay of a Professor.
Denominational........	218	2,802	$3,305,930	13	$15,165	$1,180
State Institutions.......	58	1,461	2,617,210	25	45,120	1,787
Non-Denominational..	51	1,944	3,708,220	38	72,710	1,907
	327	6,207	$9,631,360			

burdens that they have had to bear' 'from the shoulders of hundreds of hard-working and ill-compensated men' is more problematical. These hard-working and ill-compensated professors are not so badly off after all, and if their salaries have not increased in proportion to the greater cost and higher standards of living, they should themselves see to it that justice is done. Harvard, Yale, Columbia, Cornell and other universities already had pension systems as a matter of contract with their professors, and if it is intended that Mr. Carnegie's foundation shall be of benefit to the professors, their salaries should be increased by the amount of income set free. It is quite possible that professors will in the end be paid just so much the less, because pensions have been assured to them. The individual professor would probably have gained more and certain institutions would have gained less if the trustees had been professors instead of presidents.

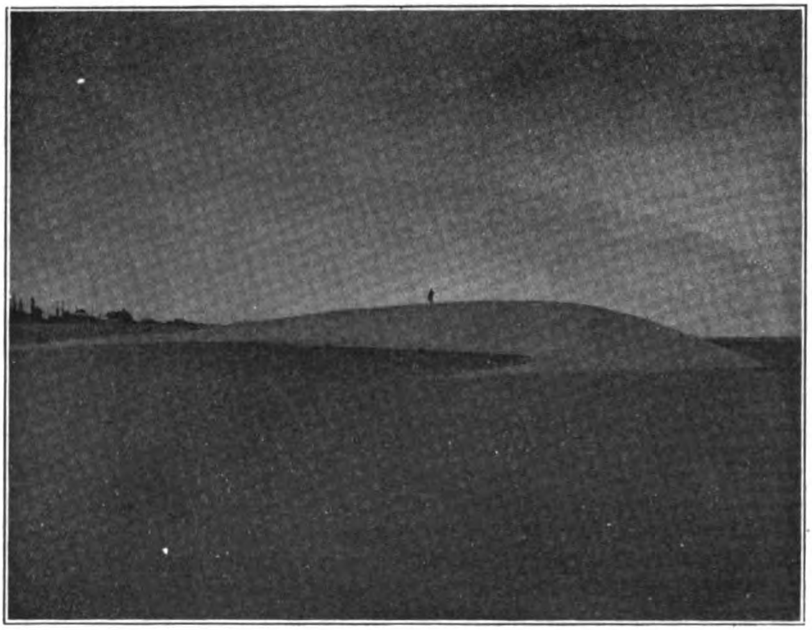
President Pritchett says in his report: "It is evident to the trustees that, to better the profession of the teacher and to attract into it increasing numbers of strong men, it is necessary that the retiring allowance should come as a matter of right, not as a charity. No ambitious and independent professor wishes to find himself in the position of accepting a charity or a favor, and the retiring allowance system simply as a charity has little to commend it." But unfortunately the pensions of widows and for disablement are at present on a charity basis. They should either be abandoned, or made so that they will accrue as a matter of contract. In the German universities a professor receives his salary for life. He may cease lecturing if disabled by illness or old age, but he may continue to lecture as long as he sees fit to such students as care to hear him. In case of death a pension is provided for his widow and for each child. This is more satisfactory than the system proposed by the Carnegie Foundation. However, it might not be possible to adjust it to the American college. Certainly all professors and all scientific men should be sincerely grateful to Mr. Carnegie. But it is a misfortune that he did not make professors trustees of the Carnegie Foundation and scientific men trustees of the Carnegie Institution.

THE SAND-DUNES OF THE DESERT OF ISLAY

It is a familiar fact that sand-dunes are carried along by the winds. Much labor and expense have been incurred in many localities, especially near the sea, to prevent the damage which their movement inflicts on the neighboring country. These sand-hills are found in great numbers in nearly all the desert regions of the earth, and their forms and motions have been described by different writers. A recent volume of the *Annals* of the Harvard Observatory contains a somewhat elaborate discussion of the crescent-shaped sand-dunes of the Desert of Islay in Peru, by Professor S. I. Bailey, who observed them during eight years.

The coast region of Peru is desert throughout its whole extent. In some places it is made up of barren hills, in others, of arid plains. The Pampa, or Desert of Islay, is bounded by the

Andes, the Pacific, and the rivers Vitor and Tambo. Its length and breadth are about equal, perhaps fifty miles in extent. The mean elevation of the pampa is about four thousand feet, increasing toward the north. It is a great plain with occasional low hills, almost devoid of animal and vegetable life, except among the low hills facing the sea. It appears to have been formerly the bed of the ocean. The surface is composed of sand, sprinkled over with stones and small boulders, and an occasional outcrop of rock.



A SAND-DUNE on the Desert of Islay.

Scattered over the pampa, especially in its northern portion, are hundreds of crescent-shaped sand-dunes. Their form is always the same, approximately that of the new moon, unless some unusual object is encountered by the dunes in their journey across the desert. Their motion seems to be always toward the north or northwest, in the same direction as that of the prevailing south and southeast wind. The convex surface is directed toward the wind, and the cusps lie in the direction of motion. Their size varies between rather wide limits. They are in general from one hundred to two hundred feet broad, and from ten to twenty feet high. They are composed entirely of a fine gray sand, and are moved along by the wind so perfectly that not only is the crescent form preserved, but none of the sand is left behind to mark the passage. A casual glance at the surface of the pampa detects little if any of the sand which enters into the composition of the dunes. The same variety of sand is found, however, by digging beneath the surface. It appears that all the available surface sand has already been collected by the wind into these symmetrical heaps, and that, unless the surface is disturbed by some convulsion of nature, the dunes may all finally disappear among the hills on the north of the desert. This theory seems to be confirmed by the abundance of dunes in the northern part of the desert, and their absence from the southern part. The motion is always to the north but varies somewhat with the season and the strength of the wind. Tables and curves are given in the discussion, showing the relations between the rate of motion and the wind. Only the comparatively strong winds are able to move the sand. During the year 1900 the wind was recorded stronger than ten miles per hour 1,477 times, of which the wind was southerly 1,414 times, and in all other directions only 63 times. The strongest winds are always southerly, reaching at times 20 miles per hour. Northerly winds are not strong and persistent enough to break up the symmetrical form of the dunes. The following brief table gives the mean monthly motion of the dunes:

Month.	Movement. Feet per Month.	Movement. Inches per Day.
January	5.6	2.2
February	7.1	3.0
March	6.0	2.3
April	3.4	1.3
May	2.7	1.1
June	3.2	1.3
July	3.0	1.2
August	3.9	1.5
September	5.9	2.4
October	6.6	2.5
November	8 0	3.2
December	5.9	2.3

The crescent shape is well preserved as the dune advances, except where the force or direction of the wind is affected by some adjacent object. The sand-dunes are formed in different parts of the desert, and move across it till they reach the hills on the northern border. These low hills are the burial places of the dunes. As individuals they go to pieces as soon as they touch these irregular formations, and become merely confused heaps of sand. Assuming the average journey, which they travel, to be twenty-five miles, since the mean yearly motion is about sixty-one feet, the life of a sand-dune may be estimated at more than 2,000 years. Since the desert is somewhat broken in places by ravines and low hills, it is probable that but few of them make the full journey without at some time losing their identity.

SCIENTIFIC ITEMS

THE national scientific societies which met in New York City during convocation week elected presiding officers as follows: The American Society of Naturalists, Professor J. Playfair McMurrich, University of Michigan; The Astronomical and Astrophysical Society of America, Professor E. C. Pickering, Harvard College Observatory; The American Mathematical Society, Professor H. S. White, Vassar College; The American Physical Society, Professor E. L. Nichols, Cornell University; The American Chemical Society, Professor T. Marston Bogert, Columbia University; The Association of American Geographers, Professor Angelo Heilprin, Yale University; The American Physiological Society, Professor W. H. Howell, The Johns Hopkins University; The Society of Vertebrate Paleontologists, Professor Bashford Dean, Columbia University, The American Entomological Society, Professor J. H. Comstock, Cornell University; The American Botanical Society, Professor George F. Atkinson, Cornell University; The American Psychological Association, Dr. Henry Rutgers Marshall, New York City; The American Philosophical Association, Professor H. N. Gardiner, Smith College; The American Anthropological Society, Professor Franz Boas, Columbia University.

DR. WILLIAM H. WELCH, Dr. Henry S. Pritchett and the Hon. William H. Taft have been elected trustees of the Carnegie Institution.

THE Brazilian government proposes to establish a national geological survey under the direction of Dr. O. A. Derby, who was for many years geologist of the state of S. Paulo. Dr. Derby went to Brazil in 1875, as a member of the extinct commissão geologica, of which Professor C. F. Hartt was the chief. He has lived in Brazil ever since, and is the leading authority on Brazilian geology.—Professor J. A. Bownocker, of the State University, has been appointed state geologist of Ohio to succeed Professor Edward Orton, Jr., resigned.—The lords commissioners of the admirality have appointed Syndey S. Hough, Esq., F.R.S., chief assistant to the astronomer at the observatory, Cape of Good Hope, to be astronomer at that observatory on the retirement of Sir David Gill, K.C.B.

Dr. William A. Noyes, head of the department of chemistry in the Bureau of Standards, and secretary and editor of the American Chemical Society, has been elected professor of chemistry in the University of Illinois. —Professor Ernest Rutherford, Macdonald professor of physics in McGill University, has been appointed to succeed Professor Schuster as Langworthy professor and director of the physical laboratories at the University of Manchester.—Dr. William Duane, professor of physics in the University of Colorado, at Boulder, has resigned to accept a position in the Curie Radium Laboratory at Paris. The fund providing for Dr. Duane's work is the gift of Mr. Andrew Carnegie.

At the annual banquet of the National Geographic Society the first award of its gold medal was made to Commander Peary.—Professor T. W. Richards has been elected an honorary member of the Royal Institution of Great Britain.—Mr. Alexander Agassiz has chartered the steam yacht *Virginia* for a cruise to the West Indies. The yacht will sail from New York the first week in February to be absent for three months.

Mr. John D. Rockefeller has given the University of Chicago $2,700,000 for its permanent endowment, and $217,000 for current expenses and special purposes. It is further reported that Mr. Rockefeller will give $3,000,000 for a pension at the University of Chicago, and $2,000,000 for the proposed Louisville University.

THE POPULAR SCIENCE MONTHLY

MARCH, 1907

A DEFENCE OF PRAGMATISM[1]

I. Its Mediating Office

By Professor WILLIAM JAMES

Harvard University

IN the preface to that admirable collection of essays of his called *Heretics,* Mr. Chesterton writes these words:

> There are some people—and I am one of them—who think that the most practical and important thing about a man is still his view of the universe. We think that for a landlady considering a lodger, it is important to know his income, but still more important to know his philosophy. We think that for a general about to fight an enemy, it is important to know the enemy's numbers, but still more important to know the enemy's philosophy. We think the question is not whether the theory of the cosmos affects matters, but whether in the long run anything else affects them.[2]

I think with Mr. Chesterton in this matter. I know that you, ladies and gentlemen, have a philosophy, each and all of you, and that the most interesting and important thing about you is the way in which it determines the perspective in your several worlds. You know the same of me. And yet I confess to a certain tremor at the audacity of the enterprise which I am about to begin. For the philosophy which is so important in each of us is not a technical matter, it is our more or less dumb sense of what life honestly and deeply means. It is only partly got from books; it is our individual way of just seeing and feeling the total push and pressure of the cosmos.

[1] The first of a course of eight lectures on 'Pragmatism: A new name for an old way of thinking,' given before the Lowell Institute, Boston, and the Departments of Philosophy and Psychology, Columbia University.

[2] G. K. Chesterton, 'Heretics,' London and New York, 1905, p. 15.

I have no right to assume that many of you are students of the cosmos in the class-room sense, yet here I stand desirous of interesting you in a philosophy which to no small extent has to be technicaly treated. I wish to fill you with sympathy with a contemporaneous tendency in which I profoundly believe, and yet I have to talk like a professor to you who are not students. Whatever universe a professor believes in must at any rate be a universe that lends itself to lengthy discourse. A universe definable in two sentences is something for which the professorial intellect has no use. No faith in anything of that cheap kind! I have heard friends and colleagues try to popularize philosophy in this very hall, but they soon grew technical, and then dry, and the results were only partially encouraging. So my enterprise is a bold one. The founder of pragmatism himself recently gave a course of lectures at the Lowell Institute with that very word in its title—flashes of brilliant light relieved against Cimmerian darkness! None of us, I fancy, understand *all* that he said—yet here I stand, making a very similar venture.

I risk it because the very lectures I speak of *drew*—they brought good audiences. There is, it must be confessed, a curious fascination in hearing deep things talked about, even though neither we nor the disputants understand them. We get the problematic thrill, we feel the presence of the vastness. Let a controversy begin in a smoking-room anywhere, about free-will or God's omniscience, or good and evil, and see how every one in the place pricks up his ears. Philosophy's results concern us all most vitally, and philosophy's queerest arguments tickle agreeably our sense of subtlety and ingenuity.

Believing in philosophy myself devoutly, and believing also that a kind of new dawn is breaking upon us philosophers, I feel impelled, *per fas aut nefas,* to try to impart to you some news of the situation.

Philosophy is at once the most sublime and the most trivial of human pursuits. It both works in the minutest crannies and opens out the widest vistas. It 'bakes no bread,' as has been said, but it can inspire our souls with courage; and repugnant as its manners, its doubting and challenging, its quibbling and dialectics, often are to common people, no one of us can get along without the far-flashing beams of light it sends over the world's perspectives. These illuminations, at least, and the contrast-effects of darkness and mystery that accompany them, give to what it says an interest that is more than professional or technical.

The history of philosophy is to a great extent that of a certain clash of human temperaments. Undignified as such a treatment may seem to some of my colleagues, I shall have to take account of this clash and explain a good many of the divergencies of philosophers by it. Of whatever temperament a professional philosopher is, he tries when philosophizing to sink the fact of his temperament. Temperament is no conventionally recognized reason, and he urges impersonal reasons only for his conclusions. Yet his temperament really gives him a stronger bias than any of his more strictly objective premises. It loads the evidence for him one way or the other, making for a more sentimental or a more hard-hearted view of the universe, just as this or that fact or principle would. He *trusts* his temperament. Wanting a universe that suits it, he believes in any representation of the universe that does suit it. He feels men of opposite temper to be out of key with the world's character, and in his heart considers them incompetent, and 'not in it,' in the philosophic business, even though they may far excel him in dialectical ability.

Yet in the forum he can make no claim, on the bare ground of his temperament, to superior discernment or authority. There arises thus a certain insincerity in the philosophic discussion. The potentest of all our premises is never mentioned. I am sure it would contribute to clearness if in these lectures we should break this rule and mention it, and I accordingly feel free to do so.

Of course I am talking here of very positively marked men, men of radical idiosyncracy, who have set their stamp and likeness on philosophy and figure in its history. Plato, Locke, Hegel, Spencer, are such temperamental thinkers. Most of us have, of course, no very definite intellectual temperament, we are a mixture of opposite ingredients, each one present very moderately. We hardly know our own preferences, in abstract matters; some are easily talked out of them, and end by following the fashion or taking up with the beliefs of the most impressive philosopher in their neighborhood, whoever he may be. But the one thing that has *counted* so far in philosophy is that a man should *see* things, see them straight in his own peculiar way, and be dissatisfied with any opposite way of seeing them. There is no reason to suppose that this strong temperamental vision is from now onward to count no longer in the history of man's beliefs.

Now the particular difference of temperament that I have in mind in making these remarks is one that has counted in literature, art, government and manners as well as in philosophy. In manners we find formalists and free and easy persons. In government, authoritarians and anarchists. In literature, purists or academicals, and realists. In art, classics and romantics. You recognize these contrasts as familiar; well, in philosophy we have a very similar contrast expressed in the pair of terms 'rationalist' and 'empiricist,' 'empiricist' meaning your lover of facts in all their crude variety, 'rationalist' meaning your devotee to abstract and eternal principles. No one can live an hour without both facts and principles, so it is a difference rather of emphasis, yet it breeds antipathies of the most pungent character between those who lay the emphasis differently; and we shall find it extraordinarily convenient to express a certain contrast in men's ways of taking their universe, by talking of the 'empiricist' and of the 'rationalist' temper. These terms make the contrast simple and massive.

More simple and massive than are usually the men of whom the terms are predicated. For every sort of permutation and combination is possible in human nature; and if I now proceed to define more fully what I have in mind when I speak of rationalists and empiricists, by adding to each of those titles some secondary qualifying characteristics, I beg you to regard my conduct as to a certain extent arbitrary. I select types of combination that nature offers very frequently, but by no means uniformly, and I select them solely for their convenience in helping me to my ulterior purpose of characterizing pragmatism. Historically we find the terms 'intellectualism' and 'sensationalism' used as synonyms of 'rationalism' and 'empiricism.' Well, nature seems to combine most frequently with intellectualism an idealistic and optimistic tendency. Empiricists on the other hand are not uncommonly materialistic, and their optimism is apt to be decidedly conditional and tremulous. Rationalism is always monistic. It starts from wholes and universals and makes much of the unity of things. Empiricism starts from the parts, and makes of the whole a collection—is not averse therefore to calling itself pluralistic. Rationalism usually considers itself more religious than empiricism, but there is much to say about this claim, so I merely mention it. It is a true claim when the individual rationalist is what is called a man of feeling, and when the individual empiricist prides himself on being hard-headed. In that case the rationalist will usually also be in favor of what is called free-will, and the empiricist will be a fatalist—I use the terms most popularly current. The rationalist finally will be of dogmatic temper in his affirmations, while the empiricist may be more sceptical and open to discussion.

I will write these traits down in two columns. I think you will practically recognize the two types of mental make-up that I mean if I head the columns by the titles 'tender-minded' and 'tough-minded' respectively.

THE TENDER-MINDED	THE TOUGH-MINDED
Rationalistic (going by 'principles'),	Empiricist (going by 'facts'),
Intellectualistic,	Sensationalistic,
Idealistic,	Materialistic,
Optimistic,	Pessimistic,
Religious,	Irreligious,
Freewillist,	Fatalistic,
Monistic,	Pluralistic,
Dogmatical.	Sceptical.

Pray postpone for a moment the question whether the two contrasted mixtures which I have written down are each inwardly coherent and self-consistent or not—I shall very soon have a good deal to say on that point. It suffices for our immediate purpose that tender-minded and tough-minded people, characterized as I have written them down, do both exist. Each of you probably knows some well-marked example of each type, and you know what each example thinks of the example on the other side of the line. They have a low opinion of each other. Their antagonism, whenever as individuals their temperaments have been intense, has formed in all ages a part of the philosophic atmosphere of the time. It forms a part of the philosophic atmosphere to-day. The tough think of the tender as sentimentalists and soft-heads. The tender feel the tough to be unrefined, callous, or brutal. Their mutual reaction is very much like that that takes place when Bostonian tourists mingle with a population like that of Cripple Creek. Each type believes the other to be inferior to itself; but disdain in the one case is mingled with amusement, in the other it has a dash of fear.

Now, as I have already insisted, few of us are tender-foot Bostonians pure and simple, and few are typical Rocky Mountain toughs, in philosophy. Most of us have a hankering for the good things on both sides of the line. Facts are good, of course—give us lots of facts. Principles are good—give us plenty of principles. The world is indubitably one if you look at it in one way, but as indubitably is it many, if you look at it in another. It is both one and many—let us adopt a sort of pluralistic monism. Everything, of course, is necessarily determined, and yet of course our wills are free: a sort of free-will determinism is the true philosophy. The evil of the parts is undeniable; but the whole can't be evil: so practical pessimism may be combined with metaphysical optimism. And so forth—your ordinary philosophic layman never being a radical, never straightening out his system, but living vaguely in one plausible compartment of it or another to suit the temptations of successive hours.

But some of us are more than mere laymen in philosophy. We are worthy of the name of amateurs, and are vexed by too much inconsistency and vacillation in our creed. We cannot preserve a good intellectual conscience so long as we keep mixing incompatibles from opposite sides of the line.

And now I come to the first positively important point which I wish to make. Never were as many men of a decidedly empiricist proclivity in existence as there are at the present day. Our children, one may say, are almost born scientific. But our esteem for facts has not neutralized in us all religiousness. It is itself almost religious. Our scientific temper is devout. Now take a man of this type, and let him be also a philosophic amateur, unwilling to mix a hodge-podge system after the fashion of a common layman, and what does he find his situation to be in this blessed year 1906? He wants facts; he wants science; but he also wants a religion. And being an amateur and not an independent originator in philosophy he naturally looks for guidance to the experts and professionals whom he finds already in the field. A very large number of you here present, possibly a majority of you, are amateurs of just this kind.

Now what sorts of philosophy do you find actually offered to meet your need? You find an empirical philosophy that is not religious enough, and a religious philosophy that is not empirical enough for your purpose. If you look to the quarter where facts are most considered you find the whole tough-minded program in operation, and the 'conflict between science and religion' in full blast. Either it is that Rocky Mountain tough of a Haeckel with his materialistic monism, his ether-god and his jest at *our* God as a 'gaseous vertebrate,' or it is Spencer treating the world's history as a redistribution of matter and motion solely, and bowing religion politely out at the front door: she may indeed continue to exist, but she must never show her face inside the temple.

For one hundred and fifty years past the progress of science has seemed to mean the enlargement of the material universe and the diminution of man's importance. The result is what one may call the growth of naturalistic or positivistic feeling. Man is no lawgiver to nature, he is an absorber. She it is who stands firm; he it is who must accommodate himself. Let him record truth, cold though it be, and submit to it! The romantic human spontaneity is gone, the vision is materialistic and depressing. Ideals appear as inert by-products of physiology, what is higher is explained by what is lower and treated forever as a case of 'nothing but'—nothing but something else of a quite inferior sort. You get, in short, a materialistic universe, in which only the radically tough-minded can live congenially.

If now, on the other hand, you turn to the religious quarter for consolation, and take counsel of the tender-minded philosophies, what do you find?

Religious philosophy in our day and generation is, among us English-reading people, of two main types. One of these is more radical and aggressive, the other has more the air of fighting a slow retreat. By the more radical wing of religious philosophy I mean the so-called transcendental idealism of the Anglo-Hegelian school, the philosophy of such men as Green, the Cairds, Bosanquet and Royce. This philosophy has greatly influenced the more studious members of our protestant ministry. It is pantheistic, and undoubtedly it has already blunted the edge of the traditional theism in protestantism at large.

That theism remains, however. It is the lineal descendent, through one stage of concession after another, of the dogmatic scholastic theism still taught rigorously in the seminaries of the Catholic Church. For a long time it used to be called among us the philosophy of the Scottish school. It is what I meant by the philosophy that has the air of fighting a slow retreat. Between the encroachments of the Hegelians and other 'philosophers of the absolute,' on the one hand, and those of the scientific evolutionists and agnostics, on the other, the men that give us this kind of a philosophy, James Martineau, Professor Bowne, Professor Ladd and others, must feel themselves rather tightly squeezed. Fair-minded and candid as you like, this philosophy is not radical in temper. It is eclectic, a thing of compromises, that seeks a *modus vivendi* above all things. It accepts the facts of Darwinism, the facts of cerebral physiology, but it does nothing active or enthusiastic with them. It lacks the victorious and agressive note. It lacks *prestige* in consequence, whereas absolutism has a certain *prestige* due to the more radical style of it.

These on the whole are what you have to choose between if you turn to the tender-minded school. And if you are the lovers of facts I have supposed you to be, you find the trail of the serpent of rationalism, of intellectualism, over everything that lies on that side of the line. You escape indeed the materialism that goes with the reigning empiricism; but you pay for your escape by losing contact with the concrete parts of life. The more absolutistic philosophers dwell on so high a level of abstraction that they never even try to come down. The absolute mind which they offer us, the mind that makes our universe by thinking it, might, for all they ever tell us to the contrary, have made any one of a million other universes just as well as this. You can deduce no single actual particular from the notion of it. It is compatible with any state of things whatever being true here below. And the theistic God is almost as sterile a principle. You have to go to the world which he has created to get any inkling of his actual character, he is the kind of God that has once for all made that kind of a world. Yet the theistic writers do not replace the old rationalist definitions of him by any new empirical constructions. Their system still lives on purely abstract heights. Absolutism has a certain sweep and dash about it, while the usual theism is more 'insipid.' But both are equally remote and vacuous. What *you* want is a philosophy that will not only exercise your powers of intellectual abstraction, but that will also make connection with this actual world of our own finite human experiences.

You want a system that will combine both things, the scientific loyalty to facts and willingness to take account of them, the spirit of adaptation and accommodation, in short, but also the old confidence in human values and the resultant spontaneity—and this is then your dilemma. You find the two parts of your *quæsitum* hopelessly separated, you find empiricism with irreligion; or else a rationalistic philosophy that indeed may call itself religious but that keeps out of all definite touch with concrete facts and joys and sorrows.

I am not sure how many of you live close enough to philosophy to realize fully what I mean by the last reproach, so I will dwell a little longer on that unreality in all rationalistic systems by which your serious believer in facts is so apt to feel repelled.

I wish that I had saved the first couple of pages of a thesis which a student handed me a year or two ago. They illustrated my point so clearly that I am sorry I can not read them to you now. This young man, who was a graduate of some western college, began by saying that he had always taken for granted that when you entered a philosophic class-room you had to open relations with a universe entirely distinct from the one you left behind you in the street. The two were supposed, he said, to have so little to do with each other, that you could not possibly occupy your mind with them at the same time. The world of concrete personal experiences to which the street belongs is multitudinous beyond imagination, tangled, muddy, painful and perplexed. The world to which your philosophy-professor introduces you is simple, clean and noble. The contradictions of real life are absent from it. Its architecture is classic. Principles of reason trace its outlines, logical necessities cement its parts. Purity and dignity are what it most expresses. It is a kind of marble temple shining on a hill.

In point of fact it is far less an account of this actual world than a clear addition built upon it, a classic sanctuary in which the rationalist fancy may take refuge from the intolerably confused and gothic character which mere facts present. It is no *explanation* of our concrete universe, it is another thing altogether, a substitute for it, a remedy, a way of escape.

Its temperament, if I may use the word temperament here, is utterly alien to the temperament of existence in the concrete. *Refinement* is what characterizes our intellectualist philosophies. They exquisitely satisfy that craving for a refined object of contemplation which is so powerful an appetite of the mind. But I ask you in all seriousness to look abroad on this colossal universe of concrete facts, on their awful bewilderments, their surprises and cruelties, on the wildness which they show, and then to tell me whether 'refined' is the one inevitable adjective that springs to your lips, when you endeavor to express the temperament of what you see.

Refinement has its place in things, true enough. But a philosophy that breathes out nothing but refinement will never satisfy the empiricist temper of mind. It will seem rather a monument of artificiality. So we find men of science preferring to turn their backs on metaphysics as on something altogether cloistered and spectral, and practical men shaking philosophy's dust off their feet and following the call of the wild.

Truly there is something a little ghastly in the satisfaction with which a pure but unreal system will fill a rationalist mind. Leibnitz was a rationalist mind, with infinitely more interest in facts than most rationalist minds can show. Yet if you wish for superficiality incarnate, you have only to read that charmingly written Theodicée of his, in which he sought to justify the ways of God to man, and to prove that the world we live in is the best of possible worlds. Let me quote a specimen of what I mean.

Among other obstacles to his optimistic philosophy, it falls to Leibnitz to consider the number of the eternally damned. That it is infinitely greater, in our human case, than that of those saved he assumes as a premise from the theologians, and then proceeds to argue in this way. Even then, he says:

> The evil will appear as almost nothing in comparison with the good, if we once consider the real magnitude of the City of God. Coelius Secundus Curio has written a little book, 'De Amplitudine Regni Cœlestis,' which was reprinted not long ago. But he failed to compass the extent of the kingdom of the heavens. The ancients had small ideas of the works of God. . . . It seemed to them that only our Earth had inhabitants, and even the notion of our antipodes gave them pause. The rest of the world for them consisted of some shining globes and a few crystalline spheres. But to-day, whatever be the limits that we may grant or refuse to the Universe we must recognize in it a countless number of globes, as big as ours or bigger, which have just as much right as it has to support rational inhabitants, though it does not follow that they need all be men. Our earth is only one among the six principal satellites of our sun. As all the fixed stars are suns, one sees how small a place among visible things our earth takes up, since it is only a satellite of one among them. Now all these suns *may* be inhabited by none but happy creatures; and nothing obliges us to believe that the number of damned persons is very great; for *a very few instances and samples would suffice for the utility which good draws from evil.* Moreover, since there is no reason to suppose that there are stars everywhere, may there not be a great space beyond the region of the stars? And this immense space, surrounding all this region, . . . may be replete with happiness and glory. . . . What now becomes of the consideration of our Earth and of its denizens? Does it not dwindle to something incomparably less than a physical point, since our earth is but a point compared with the distance of the fixed stars. Thus the part of the universe which we know, being almost lost in nothingness compared with that which is unknown to us, and yet which we are obliged to admit; and all the evils that we know lying in this almost-nothing; it follows that the evils may be almost-nothing in comparison with the goods that the Universe contains.

Leibnitz continues elsewhere:

> There is a kind of justice which aims neither at the amendment of the criminal, nor at furnishing an example to others, nor at the reparation of the

injury. This justice is founded in pure fitness, which finds a certain satisfaction in the expiation of a wicked deed. The Socinians and Hobbes objected to this punitive justice, which is properly vindictive justice and which God has reserved for himself at many junctures. . . . It is always founded in the fitness of things, and satisfies not only the offended party, but all wise lookers-on, even as beautiful music or a fine piece of architecture satisfies a well-constituted mind. It is thus that the torments of the damned continue, even though they serve no longer to turn any one away from sin, and that the rewards of the blest continue, even though they confirm no one in good ways. The damned draw to themselves ever new penalties by their continuing sins, and the blest attract ever fresh joys by their unceasing progress in good. Both facts are founded on the principle of fitness, . . . for God has made all things harmonious in perfection as I have already said.

Leibnitz's feeble grasp of reality is too obvious to need comment from me. It is evident that no realistic image of the experience of a damned soul had ever entered his mind. Nor had it occurred to him that the smaller is the number of 'samples' of the genus lost-soul whom God throws as a sop to the eternal fitness, the more unequitably grounded is the glory of the blest. What he gives us is a cold literary exercise, whose cheerful substance even hell-fire does not warm.

And do not tell me that to show the shallowness of rationalist philosophizing I have had to go back to a shallow wigpated age. The optimism of present-day rationalism sounds just as shallow to the fact-loving mind. The actual universe is a thing wide open, but rationalism makes systems, and systems must be closed. Perfection for men in practical life is something far off and still in process of achievement. This for rationalism is but the illusion of the finite and relative. The absolute ground of things is a perfection eternally complete.

I find a splendid example of revolt against the airy and shallow optimism of current religious philosophy in a publication of that valiant anarchistic writer Morison I. Swift. Mr. Swift's anarchism goes a little farther than mine does, but I confess that I sympathize a good deal, and some of you, I know, will sympathize heartily with his dissatisfaction with the idealistic optimisms now in vogue. He begins his pamphlet on 'Human Submission' with a series of city reporter's items from newspapers (suicides, deaths from starvation and the like) as specimens of our civilized régime. For instance:

After trudging through the snow from one end of the city to the other in the vain hope of securing employment, and with his wife and six children without food and ordered to leave their home in an upper east-side tenement house because of non-payment of rent, John Corcoran, a clerk, to-day ended his life by drinking carbolic acid. Corcoran lost his position three weeks ago through illness and during the period of idleness his scanty savings disappeared. Yesterday he obtained work with a gang of city snowshovelers, but he was too weak from illness and was forced to quit after an hour's trial with the shovel. Then the weary task of looking for employment was again resumed. Thoroughly discouraged, Corcoran returned to his home last night to find his wife and children without food and the notice of dispossession on the door. On the following morning he drank the poison.

The records of many more such cases lie before me [Mr. Swift goes on]; an encyclopedia might easily be filled with their kind. These few I cite as an interpretation of the Universe. 'We are aware of the presence of God in his world' says a writer in a recent English review. [The very presence of ill in the temporal order is the condition of the perfection of the eternal order, writes Professor Royce ('The World and the Individual,' II., 385).] 'The Absolute is the richer for every discord and for all the diversity which it embraces,' says F. H. Bradley ('Appearance and Reality,' 204). He means that these slain men make the universe richer, and that is philosophy. But while Professors Royce and Bradley and a whole host of guileless thoroughfed thinkers are unveiling Reality and the Absolute and explaining away evil and pain, this is the condition of the only beings known to us anywhere in the universe with a developed consciousness of what the universe is. What these people experience *is* Reality. It gives us an absolute phase of the universe. It is the personal experience of those best qualified in our circle of knowledge to *have* experience, to tell us *what is*. Now what does *thinking about* the experience of these persons come to, compared to directly and personally feeling it as they feel it? The philosophers are dealing in shades, while those who live and feel know truth. And the mind of mankind —not yet the mind of philosophers and of the proprietary class—but of the great mass of the silently thinking men and feeling men, is coming to this view. They are judging the universe as they have hitherto permitted the hierophants of religion and learning to judge *them*. . . .

This Cleveland workingman, killing his children and himself, is one of the elemental stupendous facts of this modern world and of this universe. It can not be glozed over or minimized away by all the treatises on God, and Love, and Being, helplessly existing in their monumental vacuity. This is one of the simple irreducible elements of this world's life, after millions of years of opportunity and twenty centuries of Christ. It is in the mental world what atoms or sub-atoms are in the physical, primary, indestructible. And what it blazons to man is the imposture of all philosophy which does not see in such events the consummate factor of all conscious experience. These facts invincibly prove religion a nullity. Man will not give religion two thousand centuries or twenty centuries more to try itself and waste human time. Its time is up; its probation is ended; its own record ends it. Mankind has not æons and eternities to spare for trying out discredited systems. . . . What is man that thou art mindful of him? Why, the answer is that thou art not mindful of him. Thou permittest him to die like a weed, though with all the fiery sorrow that a sentient being can feel.[1]

Such is the reaction of an empiricist mind upon the rationalist bill of fare. It is an absolute 'No, I thank you.' 'Religion,' says Mr. Swift, 'is like a sleep walker to whom actual things are blank.' And such, though possibly less tensely charged with feeling, is the verdict of every seriously inquiring amateur in philosophy to-day who turns to the philosophy-professors for the wherewithal to satisfy the fullness of his nature's needs. Empiricist writers give him a material-

[1] Morrison I. Swift, 'Human Submission,' Part Second, Philadelphia, Liberty Press, 1905, pp. 4–10.

ism, rationalists give him something religious, but to that religion 'actual things are blank.' He becomes thus the judge of us philosophers. Tender or tough, he finds us wanting. None of us may treat his verdicts disdainfully, for after all, his is the typically perfect mind, the mind the sum of whose demands is greatest, the mind whose criticisms and dissatisfactions are fatal in the long run.

It is at this point that my own solution begins to appear. I offer the oddly-named thing pragmatism as a philosophy that can satisfy both kinds of demand. It can remain religious like the rationalisms, but at the same time, like the empiricisms, it can preserve the richest intimacy with facts. I hope I may be able to leave many of you with as favorable an opinion of it as I preserve myself. Yet, as I am near the end of my hour, I will not introduce pragmatism bodily now. I will begin with it on the stroke of the clock next time. I prefer at the present moment to return a little on what I have said.

If any of you here are professional philosophers, and some of you I know to be such, you will doubtless have felt my discourse so far to have been crude in an unpardonable way, in an almost incredible degree. Tender-minded and tough-minded, what a barbaric disjunction! And, in general, when philosophy is all compacted of delicate intellectualities and subtleties and scrupulosities, and when every possible sort of combination and transition obtains within its bounds, what a brutal caricature and reduction of highest things to the lowest possible expression is it to represent its field of conflict as a sort of rough and tumble fight between two hostile temperaments! What a childishly external view! And again, how stupid it is to treat the abstractness of rationalist systems as a crime, and to damn them because they offer themselves as sanctuaries and places of escape, rather than as prolongations of the world of facts. Are not all our theories just remedies and places of escape? And, if philosophy is to be religious, how can she be anything else than a place of escape from the crassness of reality's surface? What better thing can she do than raise us out of our animal senses and show us another and a nobler home for our minds in that great framework of ideal principles subtending all reality, which the intellect divines? How can principles and general views ever be anything but abstract outlines? Was Cologne cathedral built without an architect's plan on paper? Is refinement in itself an abomination? Is concrete rudeness the only thing that's true?

Believe me, I feel the full force of the indictment. The picture I have given is indeed monstrously over-simplified and rude. But like all abstractions, it will prove to have its use. If philosophers can treat the life of the universe abstractly, they must not complain of an abstract treatment of the life of philosophy itself. In point of fact the picture I have given is, however coarse and sketchy, literally true. Temperaments with their cravings and refusals do determine men in their philosophies, and always will determine them. The details of systems may be reasoned out piecemeal, and when the student is working at a system, he may often forget the forest for the single tree. But when the labor is accomplished, the mind performs its big summarizing act, and the system stands over against one like a living thing, with that strange simple note of individuality which haunts our memory, like the wrath of the man, when a friend or enemy of ours is dead.

Not only Walt Whitman could write 'who touches this book touches a man.' The books of all the great philosophers are like so many men. Our sense of an essential personal flavor in each one of them, typical but indescribable, is the finest fruit of our own accomplished philosophic education. What the system pretends to be is a picture of the great universe of God. What it is,—and oh so flagrantly!—is the revelation of how intensely odd the personal flavor of some fellow creature is. Once reduced to these terms (and all our philosophies get reduced to them in minds made critical by learning) our commerce with the systems reverts to the informal, to the instinctive human reaction of satisfaction or dissatisfaction. We grow as peremptory in our rejection or admission, as when a person presents himself as a candidate for our favor. Our verdicts are couched in as simple adjectives of praise or dispraise. We measure the total character of the universe as we feel it, against the flavor of the philosophy proffered us, and one word is enough.

'Statt der lebendigen Natur,' we say, 'Da Gott die Menschen schuf hinein,'—that nebulous concoction, that wooden, that straight-laced thing, that crabbed artificiality, that musty school-room product, that sick man's dream! Away with it. Away with all of them! Impossible! Impossible!

Our work over the details of his system is indeed what gives us our resultant impression of the philosopher, but it is on the resultant impression itself that we react. Expertness in philosophy is measured by the definiteness of one's summarizing reactions, by the immediate perceptive epithet with which the expert hits such complex objects off. But great expertness is not necessary, for the epithet to come. Few people have definitely articulated philosophies of their own. But almost everyone has his own peculiar sense of a certain total character in the universe, and of the inadequacy fully to match it of the particular systems that he knows. They don't just cover *his* world. One will be too dapper, another too pedantic, a third too much of a job-lot of opinions, a fourth too morbid, and a fifth too cloistered, or what not. At any rate he, and we, know off-hand that such philosophies are out of plumb and out of key and out of 'whack,' and have no business to speak up in the universe's name. Plato, Locke, Spinoza, Mill, Caird, Hegel—I prudently avoid names nearer home!—I am sure that to many of you, my hearers, these names are little more than reminders of as many curious personal ways of falling short. It would be an obvious absurdity if such ways of taking the universe were actually true.

We philosophers have to reckon with such feelings on your part. In the last resort, I repeat, it will be by them that all our philosophies shall ultimately be judged. The finally victorious way of looking at things will be the most completely *impressive* way to the normal run of minds.

One word more—namely about philosophies necessarily being abstract outlines. There are outlines and outlines, outlines of buildings that are *fat,* conceived in the cube, by their planner, and outlines of buildings invented flat on paper, with the aid of ruler and compass. These remain skinny and emaciated even when set up in stone and mortar, and the outline already suggests that result. An outline in itself is meagre, truly, but it does not necessarily suggest a meagre thing. It is the essential meagreness of *what is suggested* by the usual rationalistic philosophies that moves empiricists to their gesture of rejection. The case of Herbert Spencer's system is much to the point here. Rationalists feel his fearful array of insufficiencies. His dry schoolmaster temperament, the hurdy-gurdy monotony of him, his preference for cheap makeshifts in argument, his lack of education even in mechanical principles, and in general the vagueness of all his fundamental ideas, his whole system wooden, as if knocked together out of cracked hemlock boards—and yet the half of England wants to bury him in Westminster Abbey.

Why? Why does Spencer call out so much reverence in spite of his weakness in rationalistic eyes? Why should so many educated men who feel that weakness, you and I perhaps, wish to see him in the Abbey notwithstanding?

Simply because we feel his heart to be *in the right place* philosophically. His principles may be all skin and bone, but at any rate his books try to mold themselves upon the particular shape of this particular world's carcase. The noise of facts resounds through all his chapters, the citations of fact never cease, he emphasizes facts, turns his face towards their quarter; and that is enough. It means the right *kind* of thing for the empiricist mind.

The pragmatistic philosophy of which I hope to begin talking in another article preserves as cordial a relation with facts, and, unlike Spencer's philosophy, it neither begins nor ends by turning positive religious constructions out of doors. It treats them cordially as well.

I hope I may lead you to find it just the mediating way of thinking that you require.

THE CENTURY PLANT, AND SOME OTHER PLANTS OF THE DRY COUNTRY[1]

BY PROFESSOR WILLIAM TRELEASE
MISSOURI BOTANICAL GARDEN

IT would be interesting if we might know whether Columbus and his fellow voyagers noticed what is oddly called 'bamboo' by the present islanders, when they first saw the Bahamas in the autumn of 1492. The plant, a striking one even to us, must have seemed still stranger to Europeans at that time, for although Meyer and others have attempted to show that the century plant was known in the Mediterranean country as early as the eleventh century, and claim has even been made to its recognition among the mural paintings of Pompeii, a thousand years earlier still, *Agave* represents an essentially American and very distinct type of vegetation which must have been novel to those travelers into a new world. At any rate—they had little time for botanizing—there is no evidence that this conspicuous element in the Bahamian landscape was among the strange animals and plants that they paraded on their return home, and, curiously enough, it remains to-day without a published description or tenable scientific name.

The discoverers must have seen at least one other species of the same type when, during this first voyage, they found the Greater Antilles; and the busy quarter of a century which followed, with its additions of the Lesser Antilles, upper South America, and a part of the Gulf coast to the map of the world, undoubtedly revealed others.

The native name 'maguey,' which still persists in Porto Rico for a species of the related genus *Furcræa,* was mentioned in Martyr's book of 1516, and seems to have sufficiently impressed itself on the minds of the adventurers to assume a generic quality, for they later transferred it to the fleshy-leaved agaves of Mexico, which the aborigines knew as 'metl,' from which it is easily inferred that they had repeatedly seen and discussed and inquired about these strange fleshy-leaved plants with tall candelabrum-like inflorescence.

The most familiar of these plants in our gardens has long borne the popular name of century plant. Everybody knows it—or thinks that he knows it—to-day. Its rather narrow, somewhat grayish-green leaves have a peculiar curvature and their ends frequently arch downwards in a characteristic hooked form, while the prickles on their margins stand

[1] A lecture delivered in the Field Museum Course at Chicago, on October 13, 1906.

on marked fleshy hummocks, and the short stout end spine is not continued down the border as it is in some species. Perhaps even commoner than the typical form are one with bright yellow stripes down the sides of the leaves, and another with rather faint yellow lines distributed over the surface; and a still finer but much less common variety has a broad stripe of yellow down the center of the leaf. Among the cultivated variegated century plants one yellow-margined form, with the green parts of a darker shade and the end spine long and slender, has been distinguished for half a century under the name *A. picta;* but, as with the variegated forms of *A. Americana,* nothing is known as to its source or the first date of its appearance. Like the unvariegated form, these yellow-margined plants are now becoming established along the Italian Riviera.

When the American aloe, as it has often been called, was a novelty in Europe, its flowering was one of the wonders of the world. Not only did its size and form and the great age reached by some plants before flowering excite interest, but odd rumors seem to have gone abroad concerning its behavior. One of these gives indirect evidence of the long persistence of a colloquial expression familiar to most of us to-day, for Philip Miller, nearly two hundred years ago, gravely assured the British public that the flowers of this plant do not really open with a report like that of firing a gun, the then prevalent impression that they do so probably coming from a misinterpretation of somebody's statement that the flowering of a century plant 'made a great noise.' The phenomenon has now become so common as to attract no attention about the Mediterranean region, on the Channel Islands, and in the warmer parts of our own country, where the plants grow out of doors and flower when they are ten or fifteen years old; but it is still a matter of much interest in the colder countries where they require the protection of glass houses and develop slowly enough to suggest, if not quite to justify, their popular name.

The century plant shares with or even surpasses the true bamboo in its reputation of offering most of the necessities of human life. Food, drink, clothing, building material, forage, military barricades, razor-strops with soap and brush, medicine, pins, needles, paper, glue and a red coloring matter are said to be afforded by it.

It is true that most of the indicated uses may be made of it, but as a matter of fact the real century plant is very little used except for ornament or as a hedge plant, though its leaf fiber is firm, fine and white and used to a limited extent for the better class of cordage or for a stiff thread peculiarly adapted to some of the ornamental lace-work of the Azores and Mediterranean countries. Nearly all its reputed uses actually refer to different if sometimes superficially similar plants which have been mistaken for it, and the literature of '*Agave Americana*' is chaotic enough to tax the patience of even a botanist.

Perhaps the most curious thing that I can say of the real *Agave Americana* is that nobody knows to-day where to seek it as a spontaneous plant, and, except about the Mediterranean, where it has spread extensively, it seems to be found only as an obvious local escape from cultivation. It looks very much as if the Spanish conquerors took home, as one of their first illustrations of the maguey, a decorative rather than a much-used plant, which even then probably existed only in cultivation.

The traveler through that wonderfully interesting dry region to the southwest of us, the Mexican tableland, has his attention attracted by many of these candelabrum-bearing agaves. Even before reaching Laredo, if he go by that gateway into the neighboring republic,

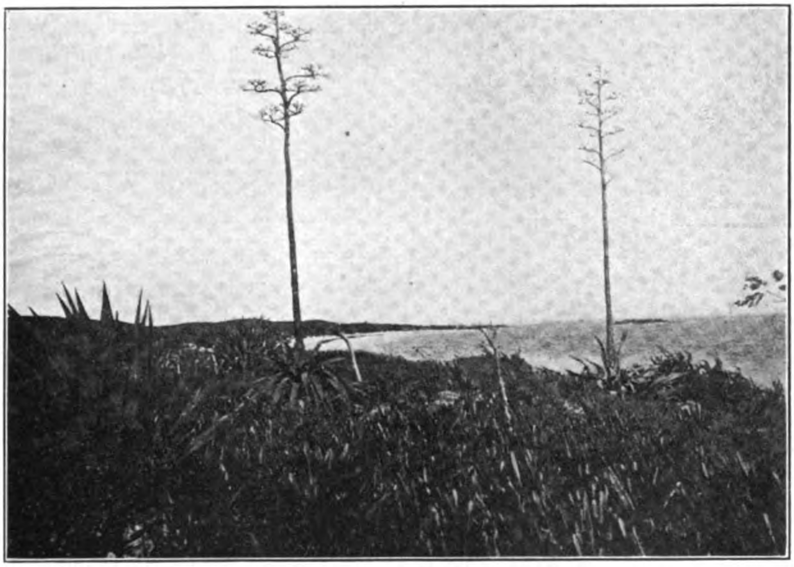


FIG. 1. ODDLY CALLED BAMBOO.

he may see one large species, *A. asperrima.* If he enter by way of El Paso from the east, another, *A. Parryi,* may draw his notice, or, coming from the west, he may have seen another, *A. Palmeri;* and toward Nogales, the entrance point for Sonora, one of the most striking of them, with almost globose clusters of leaves, *A. Huachucensis,* is visible from the train.

One of the most effective of these landscape-making plants covers certain mountain-sides near Tehuacan, a health resort which every visitor to Oaxaca and the wonderful ruins of Mitla passes through after leaving Puebla. Its stately panicles are of a brilliant yellow, and more beautiful than those of the ordinary century plant; and its great rough leaves are so marbled with alternating greener and grayer cross bands that it has received the distinctive name *A. marmorata.*

Elsewhere about the same city, in company with a full dozen other distinguishable agaves, is an abundance of the beautiful little white-leaved plant, now popular in gardens, which was named *A. Verschaffeltii* after its importer, some forty years ago.

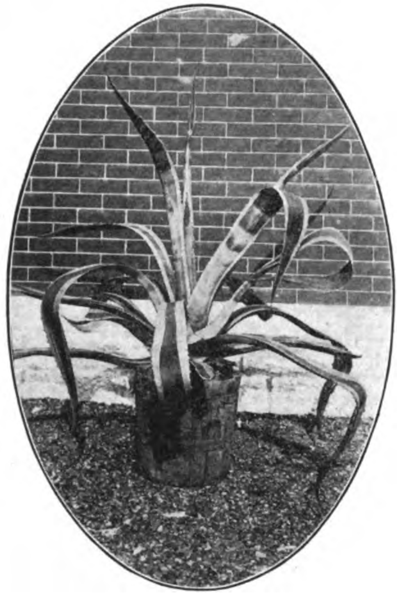


FIG 2. AGAVE PICTA.

Even in Mexico it is the planted rather than the wild agaves that attract attention. Hedgerows or dooryard specimens of them are found everywhere, and in the region to the south of the City of Mexico there are many miles of territory seemingly devoted entirely to their cultivation. Phalanx after phalanx of them stretches away to the horizon as the train speeds through, with hardly a sign of other vegetation except for a cottonwood or pepper tree now and then where water happens to occur, or a cypress marking the resting place of the dead. Through this district, centering about the little town of Apam, it is almost exclusively the dark green giant, *A. atrovirens,* which is grown, though, as with extensively cultivated plants elsewhere, in numerous horticultural varieties which look much alike to the botanist but are distinguished by the planter. Over thirty such forms are said to be planted in the plains of Apam. In the immediate suburbs of the capital city, about Tacubaya, and locally elsewhere in this central district, other forms, differing even to the unspecialized eye, are similarly grown in quantity. As one passes to the colder regions of the north or descends from the table-land into the hot country, still other and different looking species of the same type replace *A. atrovirens,* which, however, far outnumbers and surpasses them all in its aggregate farm importance. These plantations

FIG. 3. DOORYARD SPECIMENS.

are the basis of the pulque industry of Mexico—at once a large item in its agricultural wealth, and one of the greatest curses to its peon population, many of whom are kept in poverty and sottishness through it.

A philosophical historian[2] notes that man has never remained content with water as a beverage, and that agriculture, affording a means of obtaining abundant intoxicants as one possible and alluring substitute, has borne the curse of drunkenness in all ages. The discoverers of the new world found the cultivation of the maguey or metl, and the production of a fermented drink, 'octli' or 'pulque,' from its sap,

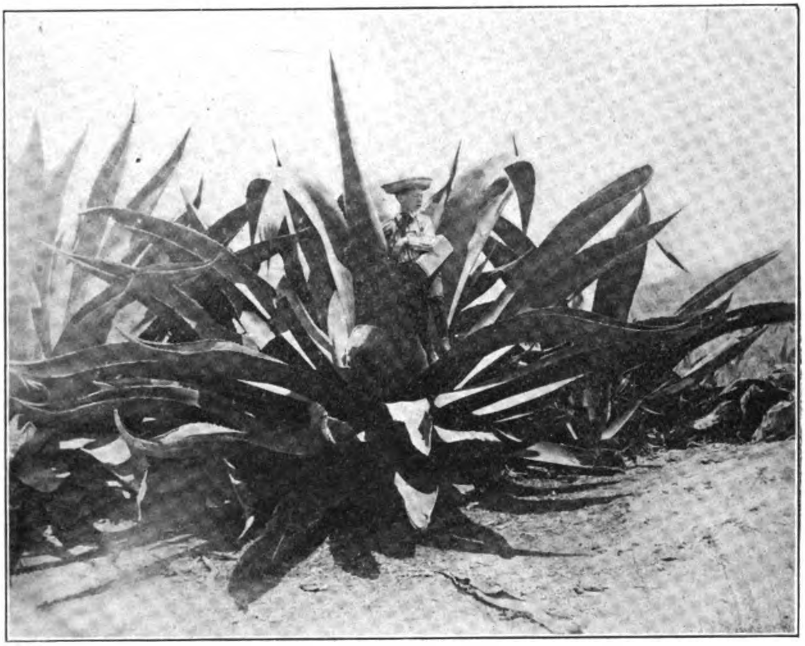


FIG. 4. THE DARK GREEN GIANT.

an established industry, which even then had worked its fatal course with the Toltec race.

The present traffic in pulque is large. Something over five million barrels of it are used in the Mexican republic every year, of which quantity about half is consumed in the capital city and much of the remainder in Puebla and the other large cities of the central plateau. Cheap as it is, for it sells for from one to three cents of Mexican money for a large glass, its aggregate value amounts to several million dollars gold, a year. Special trains are run into the City of Mexico every morning for its delivery, as is done with the milk supply of our own cities.

[2] Payne, 'History of the New World,' 1: 401, 404.

In the Apam district, the plantations are chiefly found on the large haciendas or estates. The first impression of a traveler who passes from Vera Cruz to the capital is likely to be wrong if, as is usually the case, he regard the table-land—so barren after the tropical vegetation in and below the coffee country—as a desert with this strange industry as its one resource. The observant person, however, sees, usually with surprise, enormous stacks of straw here and there in the maguey fields, each commonly marked with a great carved cross or other symbol, and all carefully trimmed into house form; and a shrewd inference that where there is a good deal of straw there must be some grain is justified on a closer acquaintance with the country.

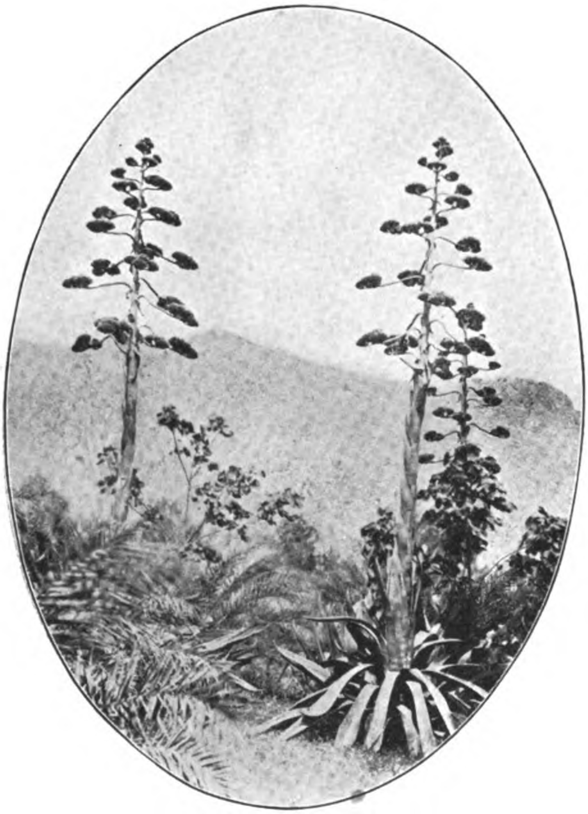


FIG. 5. IN GARDENS IN SICILY.

A first visit to a Mexican hacienda is an interesting episode in one's traveling experiences. Comfort, as we understand it, is scarcely to be had in the dustier regions during the dry season; and as one looks over the barren country it is hard to see where food is obtained for the swarm of peon retainers for whom even a church is not lacking in the walled village which their dwellings constitute. The wealth of such an estate is found in its extent. I recall the surprise with which, after a day of blinding dust on a hacienda within sight of the great snow peak of Orizaba, as I asked myself how people could find a living in such a place, I noticed the arrival of a wagon-load of dry fodder in the enclosure, quickly followed by another and another and still others, until some twenty had come in—each drawn by five mules. Then I began to realize the number of draft animals alone that were engaged in bringing in the night's food for the others, and was less surprised when, in droves of twenty or fifty, sheep and cattle began to appear from remote points—until I ceased counting and returned to my original question with even greater wonder. It is on these large estates that the maguey—almost the only green thing to be seen in the long dry season—finds its place as one of the many forms of agricultural resource; the ground between them being frequently made to yield an annual grain or other crop which the agaves supplement as, here and there, they mature one at a time.

The pulque maguey is a large plant, and its rosette of thick leaves, though appearing to lie next the ground, is really spaced along a stout trunk as large as a small barrel. The whole, charged with sap, weighs several tons. If left to itself, as it is in gardens on the Riviera, where it is called *A. Salmiana,* like the century plant it produces a gigantic scape, topped with a candelabrum of flowers, when somewhere in the neighborhood of fifteen years old. This is never permitted on the large plantations, for the plant possesses its maximum value when it has reached vegetative maturity and the scape is about to develop. At the critical moment, known from the appearance of the central bud, this is cut out and a shallow cavity is made in the crown of the trunk, which is covered by a stone, pieces of maguey leaves, or other protection. Into the cavity so formed the sap exudes. It is removed two or three times a day, the surface being scraped and the cavity slightly enlarged each time, until at last nothing but a thin shell of the trunk remains, the leaves meantime having given up their content of fluid and dried to their hard framework—as happens naturally during the flowering period of all the larger agaves, when the reserve of sap is drawn into the rapidly growing scape and flowers.

For a period of three months or more a good plant yields a gallon or two of sap daily, and its value may be not far from ten dollars on an average; from which it will be seen that a large maguey plantation represents a considerable item in the assets of a landed proprietor of the plains of Apam.

Often the peons who cut the matured plants fasten part of the bud leaves on to the spines of the outer ones, so that those in bearing may not be overlooked as the tour of the plantation is made by the laborers who gather the sap. One of these men, making his rounds, is an odd sight. Over his back, usually separated from it by a zarape or blanket if he is fortunate enough to have one, or by a piece of

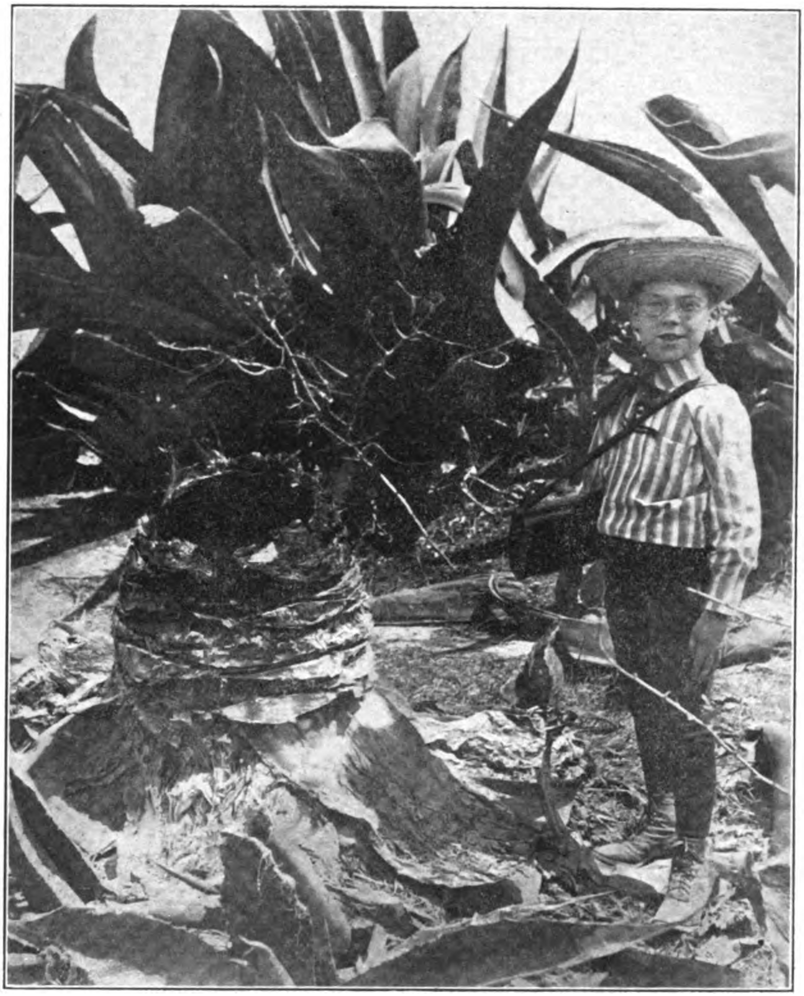


FIG. 6. A SHELL OF THE TRUNK.

sacking if he is so poor as to feel compelled to reserve his zarape for dress occasions, is swung from his forehead by a head-yoke a pig-skin, supported by a sac, or more usually by a coarse net of cordage, and sticking out from its open top is to be seen a long gourd of the type that we call the Hercules club. In his hand he carries a short curved knife. Plodding from one bearing plant to another, the Indian stops at each long enough to uncover the cavity in its crown, press the smaller end of the gourd to its bottom and, by sucking at the upper end, draw into the lower part of the gourd the exuded sap, and thrust the gourd over his shoulder into the pig-skin bag on his back—his finger meantime stopping the upper hole so that the fluid may not run out until he wishes it to. A quick scraping of the cavity follows, the stone or other cover is replaced, and he passes on. Sometimes he trudges home with his burden as often as the pig-skin is filled; but on the larger haciendas a burro, saddled with large bags of the same kind, awaits him at one side of the field, and the work continues until at length man and donkey go in with a full load.

The fluid which collects in the hollowed trunk of a cut maguey plant and is gathered in the manner described, is called 'agua miel,' or honey-water, because of its sweetness: nine or ten per cent. of its weight is sugar, and this furnishes the basis for the alcoholic fermentation which is the chief factor in its conversion into pulque. The agua miel of the Apam district is thin, clear and colorless. It is of a rather pleasant taste if dipped from the plant in a gourd and free from drowned insects, but fact or fancy gives it various reminiscent flavors under other circumstances.

The fermentation practises in pulque making are still mostly primitive. I have had a Mexican gentleman tell me that although when the agua miel was gathered and fermented in a way to please him he considered it a delicious drink, he would not think of touching pulque as offered, for instance, at the railway station in Apam—where the conversation occurred. The vats used are of ox-hide stretched on frames, and they are usually three or four feet wide and nearly as deep. Fermentation is begun by the introduction of a starter or 'mother of pulque' obtained by preliminary fermentation, and is carried on without, or at most with little, artificial control of temperature, and under conditions of positive or negative cleanliness which differ with the various haciendas.

When marketed, the pulque is a white, decidedly viscous fluid containing about eight per cent. of alcohol; fermentation has not been solely alcoholic, however, and its flavor is in part due to changes wrought by bacteria of several kinds which are introduced with the starter in company with the yeast. Continuation of the action of these collateral ferments causes the beverage to spoil in a day or two under ordinary conditions.

Familiar sights about Apam and in the capital are wagons loaded with the large casks in which pulque is transported from the haciendas to the railroad and again to the gaudily colored but often disreputable and usually filthy shops where it is dispensed—from open barrels into which glasses are plunged by hand with no greater care to prevent contact with the human person than marks some of the earlier stages in the conversion of grape juice into wine—and the patrons of which are not prepossessing.

Where the maguey, though capable of cultivation, yields a lesser or inferior product, agua miel is often more appreciated in its unfermented state. As hawked around the streets of Monterey, for instance, in porous earthenware receptacles, it is a cool yellowish fluid, that I must confess I find refreshing on a hot day—especially after I have seen it gathered by means of a long-spouted tin pump and transported in tin cans; and the limpid, yellowish, cidery, foamy product of its fermentation in the north is more to my taste than the white, viscous, odoriferous pulque of the Apam district—which alone pleases the adept.

With smaller production of pulque away from this center, more primitive methods of transportation persist; the shipping cask of the large producer, carried by a special train, may be replaced by the burro-borne pig-skin; and, as I have observed in Tuxpan, the pulque shop may give way to the street hawker, with an earthenware olla, the contents of which from time to time are freshened up by being sucked into and allowed to gush back, frothing, from a gourd of the sort used

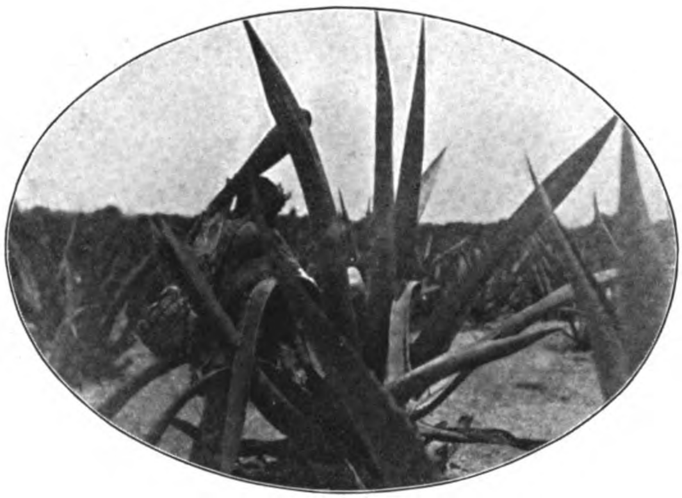


FIG. 7. MAKING HIS ROUNDS.

in gathering the agua miel—the bowls of customers being filled by aid of the same convenient implement.

Considerable medicinal virtuė has been claimed for pulque, and some efforts have been made to specially prepare, bottle and Pasteurize it for medicinal or even table use, but, except in the region of its production, where it is the common beverage, the bulk of it is used as an intoxicant, pure and simple. From it is also produced a rather small quantity of distilled liquor, 'mezcal de pulque.'

Away from the central district, where the product of a single plantation is not sufficient to keep a fermentation establishment in profitable operation, it is sometimes the practise of the growers to sell their plants, as they mature, one by one, to a maker of pulque, whose employees, trudging from one to another, attend to cutting them and gathering their sap. Under these conditions, or where the market is still less certain, the plants frequently succeed in sending up their scapes.

Fig. 8. Man and Donkey.

Sometimes flowering is permitted, and the plant yields nothing more than a light rafter-pole, capable of being sliced into good razor-strops, a little green fodder for the cattle, and a few dried leaves that may be used for thatching a hut. At other times the stalk, or 'quiote,' is cut down before the flowers have too far sapped it, stripped of its woody exterior, and cut into disks a few inches long which may be seen peddled around the streets in Durango, for instance—to be split into strips and chewed like sugar-cane. If a distillery is at hand, the leaves are often cut away from a plant of this sort, or one that has not been allowed to form its quiote, above their very thick 'pencas' or bases, and the trunk, so prepared, is marketable for the manufacture of mezcal. From data obtained of a peon, I once figured out that away from the principal pulque region the value of a plant is practically the same whether cut for agua miel or, after harvesting its quiote, sold to the mezcal distillery.

Fig. 10. Frothing from a Gourd.

Fig. 9. Where Pulque is Sold.

Mezcal is a term applied comprehensively to the liquor obtained by distillation from the fermented juices of agaves. Four or five million gallons of it a year are produced, and its value may amount to some $2,000,000 gold. The center for the manufacture of this beverage is to the west of Guadalajara, and the town of Tequila, situated there, has imposed its name on the higher grade of liquor, which is clear, smoky, rather smooth, and with a characteristic essential flavor; it usually contains forty or fifty per cent. of alcohol, and, like pulque, possesses certain medicinal properties.

Like pulque, mezcal is sold cheaply. It is to be found everywhere and contributes largely to the demoralization of the native peon, who often drinks it to excess and, like many another human type, commits most of his crimes when influenced by alcohol. Those who watched for the threatened revolution of the sixteenth of September last, probably noticed that the very wise head of the republic forestalled any large demonstration by seeing that drinking places were closed throughout the country.

To supply the distilleries at Tequila, a considerable acreage is planted to mezcal agaves. Those most used there belong to a well-marked, narrow-leaved species which a few years ago received the appropriate and distinctive name *A. Tequilana*. As with the pulque spe-

FIG. 11. QUIOTE. IN DURANGO.

cies, a number of horticultural forms of this are recognized. The leaves are generally glaucous, and a field of these white plants produces a striking effect. If allowed to bloom, this, too, develops a striking and large candelabrum of flowers; but, like the pulque maguey, it is harvested when mature but before its saccharine food reserve has been exhausted in the production of flowers and fruit. The leaves are cut back to their thick bases and the trunks, so trimmed, are packed—usually on mules—to the distillery, where, after a preliminary roasting, still in rather primitive smoky pits, they are converted into a mash which is fermented in large wooden tanks and then distilled in modern apparatus, much as is done in the production of liquors elsewhere. At these modern stills, the bagasse from which the mash has been squeezed by rollers is even packed away by half-naked laborers to be used to feed the furnaces.

In addition to this mezcal de Tequila—or plain 'tequila,' that made direct from the maguey trunks, and the mezcal de pulque already referred to, a great deal of this sort of liquor is made from wild agaves of many kinds, throughout the length and breadth of Mexico; indeed a common if not universal distinction is made between the large 'maguey' species and the smaller ones, which are called 'mezcal' like the beverage obtained from them. The process is everywhere essentially the same in so far as the preliminary roasting and fermenting processes are concerned; but the stills vary from the ordinary retort type in its simplest form, with a 'worm' cooled by flowing water, to the most primitive apparatus by which a paying part of the alcohol may be condensed into fluid form while making its escape from the kettle.

While at Mitla, a few years ago, I was directed to a distillery of this latter kind, not far from the prehistoric ruins for which the place is famed, and my companion and I were permitted to make photographs showing trimmed agave trunks newly brought in from the surrounding mountains and sheltered from the sun while kept in storage, fuel for the roasting pit, the wooden mash barrels and the maul used in crushing the roasted material, the ox-hide fermentation vats supported on rude frames of crooked wood, and the very primitive still of glazed earthenware kettles, set over a crude oven, each capped with a saucer-like metallic cover which was cooled as far as this could be done by a stream of mountain water, while below it a funnel caught the condensed liquor and passed it through a reed spout into a waiting small receptacle.

In northwestern Mexico, 'mezcal' is largely replaced by 'sotol' as the distilled drink of the peon. This liquor, which has the general character of the former, is said to be made in a similar manner from the trunks of several species of the saw-leaved lilies (*Dasylirion*) which are commonly known as sotol and in the stock country are frequently split open to enable animals to get at the pulpy nutritious contents of their stems.

Among the early stories of the new world was an account of the roasting of maguey trunks, and their use as food. They do not appear to be largely used in this manner now, except by the nomadic Indians. In the days of the Apaches, the roasting and eating of mezcal was frequently noted, and the botanist or geologist who gets back into the mountains still occasionally sees it. On our side of the boundary, however, I understand that spectators are not welcomed at a mezcal roast; and the impression has been left on the mind of one of my friends that what was not eaten of the product was likely to undergo fermentation and be saved from becoming a total loss by the aid of the still—a practise on which our government does not smile so complacently as does that of the adjoining republic. Old mezcal pits are

FIG. 12. WHITE PLANTS.

not uncommon in southern Arizona, where *Agave Palmeri* was much eaten; and they are to be seen in the Grand Canyon, in northern Arizona, where *A. Utahensis* is abundant.

The most important economic agaves are not the source of alcohol, but those which yield 'henequen,'—a native name introduced by Oviedo only a few years after Yucatan was discovered. This, so far as Mexico is concerned, is practically a product of Yucatan, though some of the other tropical states yield a small quota, and it has a yearly value of some $30,000,000 gold. A large part of it comes to the United States for use in cordage, etc., under the name 'sisal hemp' or 'sisal grass,' which is derived from a port of shipment. Our imports for the past three years average about $15,000,000 annually.

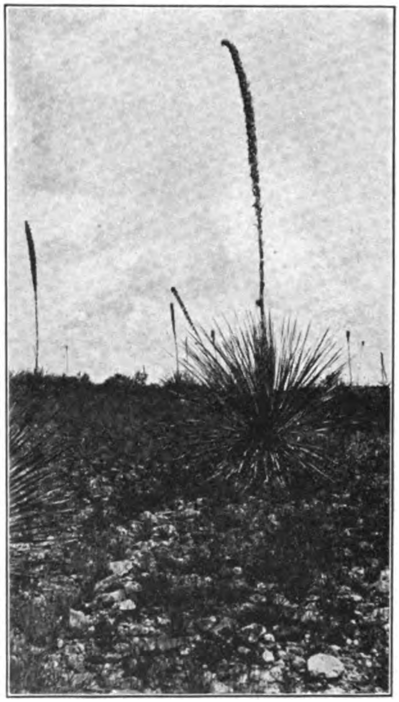


FIG. 14. SOTOL.

Most of the agaves have a strong fiber in their leaves, the use of which is prehistoric. That of the century plant is particularly white and fine, and, as I have said, is considerably used. The fiber of the pulque species, from the manner in which the sap is gathered, is little used; the very fleshy-leaved species are also hard to clean. The Tequila mezcal is said to produce a good quality of fiber, which —its harvesting not interfering with the main use of the plants— is coming to be regarded as a valuable by-product of this species; and several other agaves are either cultivated on a smaller scale for their fiber or exploited as they occur spontaneously.

FIG. 13. HALF-NAKED LABORERS.

Henequen, however, is *par-excellence the* fiber agave. An interesting minor chapter in our national evolution is contained in the numerous appeals made to Congress about seventy years ago by our former consul at Campeche, Henry Perrine, who desired a land grant in subtropical Florida for the cultivation of this and other tropical plants. The grant cost him his life, for he was killed by the Indians, and the zone of henequen in this country scarcely goes beyond the radius of his own tentative introduction of plants; but the Yucatan industry, which in Dr. Perrine's day was small, though he saw a great future for it if only the fiber could be less laboriously cleaned than it then was by hand, has grown greatly, and the Bahamas, India, Hawaii and tropical Africa are entering the field with more or less realization of their expectations of gain from this crop.

Like the pulque maguey and the Tequila mezcal, henequen is represented in the larger plantations by several horticultural forms if not by more than one distinct species. The one most grown in Yucatan appears to be the taller form with long, narrow, prickly leaves, generally known to foreigners as white or gray henequen—and usually, but wrongly, designated by botanists as *Agave rigida elongata.* A better fiber plant is the entire-leaved green henequen, called *Agave Sisalana* by Perrine, also, but to a smaller extent, grown in Yucatan, and now spontaneous in tropical Florida from Perrine's importation. It is this which has been introduced into the Bahamas and Hawaii, though both the gray and green forms are being experimented with elsewhere.

The utilization of a henequen plant is not effected abruptly at the end of its life, as with the pulque and mezcal species, but, after a wait of five or six years, it extends over a period of from seven to fourteen years, during which the annual yield is said to be from 20 to 40 leaves per plant in several gatherings—the number of mature leaves removed each year determining the longer or shorter period during which cropping may continue. One of the difficulties experienced in trying to cultivate henequen away from the limestone terraces of Yucatan has been that it goes to seed at too early an age, for this ends its usefulness instead of at the same time bringing it to fruition as is the case with the plants grown for pulque or mezcal, though its expiring energy is said to be then thrown into leaf production by cutting out the scape at its inception.

The cultivation of henequen in Yucatan is comparable with that of the maguey on the plains of Apam, in that it is now chiefly in the hands of large proprietors. Plantations are extensive, and the mills for cleaning the fiber are proportionately large. The older leaves are cut, at such intervals and in such numbers as the condition of the plants is thought to warrant, and, after the prickles have been sliced from their edges, trucked or carried on tram roads to the mill, where, while they are still fresh, by means of some form of rotary scraper (an idea tersely suggested by Perrine, and for the successful application of which, as I read, a large sum was later paid to another) the pulp is removed. The fiber, suitably washed and dried, is then baled for export. In the state of Vera Cruz a plant of the same group has recently come into local prominence, and is said to be considerably planted under the name 'zapupe,' and to yield an excellent fiber.

One of the agaves longest known in gardens is that for which botanists are now restoring the name *A. Vera Cruz* which Miller applied to it, following its earlier polynomial designation of 'Aloe America ex Vera Cruce foliis latioribus et glaucis.' Like the henequen, it yields a fiber for which it is somewhat cultivated in the state of Vera Cruz; and I understand that it is this species to which the '*Agave Americana*' of Indian fiber-culture reports refers.

In India, for a century and a half or more, has been known another agave which is properly called *A. Cantula,* though it is frequently

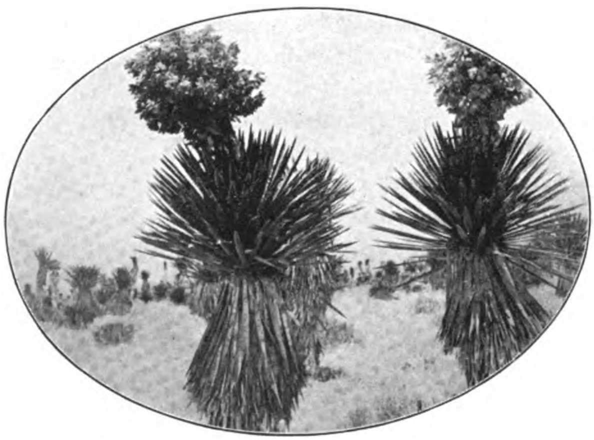


FIG. 15. PALMA ZAMANDOQUE.

spoken of under the name *A. Roxburghii,* which was given to it later. Erroneously, it is even more often designated by the name *A. vivipara,* which, as used by Linnæus, belongs to a very different plant common in the Greater Antilles. This species, the source of a considerable quantity of Indian fiber which is known in the market as Bombay aloe, and of a small but increasing amount of Philippine fiber under the name 'Manila aloe,' is a close relative of the Tequila mezcal. Adequate study will probably result in its final positive identification with some American species; but at present it shares with another Indian species of the same group the distinction of representing in Asia a genus otherwise exclusively American—if the generally discredited hypothesis that the century plant is indigenous to the Mediterranean region be not true.

In comparison with the great cultures of henequen, all of the other utilization of agaves for fiber is of rather small importance. Nevertheless, considerably more than a million dollars' worth of so-called 'ixtle' fiber is marketed in Mexico each year, in addition to a very large quantity used locally for lassoes and other cordage and the like. From the port of shipment, ixtle is commonly known as Tampico fiber. Our imports for the last three years average about one and a quarter million dollars in value. Unlike henequen, this is the product of several distinct plants, of which a number belong to the very different genera *Yucca, Samuela* and *Hesperaloe,* and in the tropics the name is also applied to *Bromelia* fiber; but the larger part of the Tampico fiber is obtained from two dwarf species of *Agave.* Comparatively little of it comes from large plantations, except in the warm region above Tampico, where extensive planting is now being undertaken—and a large part of the exported ixtle is obtained from this district. Aside from its *Hesperaloe* ('Zamandoque') and *Samuela* ('Palma Zamandoque') constituents, the longer grade of Tampico fiber—which even then is shorter than henequen—seems to be produced chiefly by an agave spontaneous as well as cultivated in the state of Tamaulipas, and known botanically as *A. Funkiana.* In the cooler country, especially in the states of Coahuila and Nuevo Leon, a shorter fiber is obtained from the closely related wild 'lecheguilla,' the native name of which has been adapted by botanists into *Agave Lecheguilla.*

On the plantations, and possibly to a very slight extent elsewhere, the fiber is cleaned by machinery, much as henequen is; but a great deal of it is still prepared laboriously by hand. It is here the central bud or 'cogollo' of young leaves, which is used, and not the harder old ones, and the pulp is removed from the fiber by means of a hand scraper of metal used against a supporting block of wood.

In the northern part of the republic, where, as in western Texas, lecheguilla is extremely abundant over a large area, the extracted fiber, sometimes used for brushes, bath pledgets, etc., is usually spun by hand into cords or these into ropes on a primitive rope-walk, a child twirling the strands as they grow from the apron-like bag of fiber carried by the spinner. This is the common cordage of the country, and is used for tying purposes, lariats and the like, as well as to make sacking, saddle-bags, and the head-yokes with which the human beast of burden always goes provided in that land. Visitors to Monterey are often interested in the rope-walks, which may be seen anywhere in the outskirts of the city, as well as in the manufacture of the lecheguilla cord into coarse bagging which is effected in an equally laborious and simple manner—the cord being woven into oblong mats which are then folded across the middle and stitched down the sides, everything being done by hand. The charm of these simple sights to the tourist is largely enhanced by the general friendliness of the workers, who are usually willing to chat or be photographed and whose

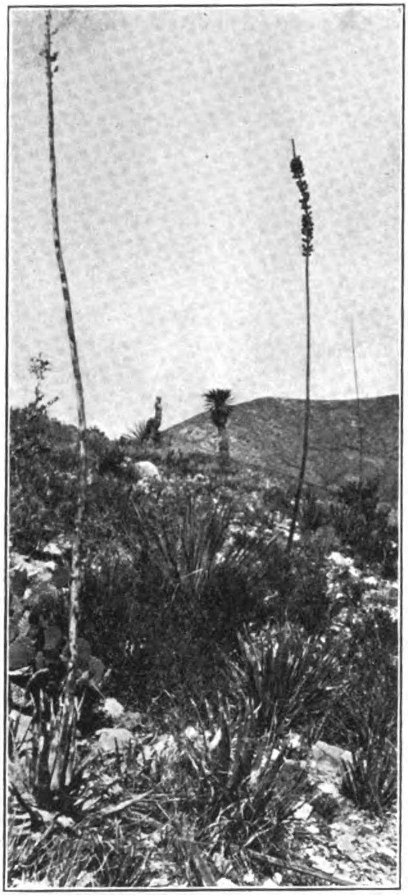


FIG 16. SECHNGUILLA.

affection for their children is an unfailing and very pleasing sight, but the poverty of their homes, only too evident to even the less prying sight-seer, is scarcely compensated for even in this affection —which appears to me the best quality of the Mexican peon.

The lecheguilla agave well pictures a division of the genus in which the flowers are clustered along the upper part of the scape instead of being disposed on the branches of a candelabrum-like top. Of this type is further the 'guapilla'—*A. falcata*—a very narrow-leaved small species of the region about Saltillo, which also yields good ixtle.

The minor uses of agaves are hardly worthy of detailed mention in comparison with their commercially important use as a source of fiber and alcohol. These uses, however, are many, as I have already said. Under the name 'amole' one may buy in most Mexican market places either leaf bases of agaves like *A. filifera* or,

FIG. 17. SPINNING AND WEAVING.

more commonly, rootstocks of the so-called herbaceous species, for use as vegetable soap; the claim has recently been made that the sap from henequen leaves in process of cleaning can be converted into a valuable glue; and from the time of the Aztecs innumerable domestic uses have been found for one part or another of these interesting plants.

So far as inference may go, it was none of the agaves of the earlier discovered West Indies or Yucatan which was first taken across the water, in small specimens for gardeners to care for and grow into some semblance to their native form and size, but one or more species from Mexico proper, to illustrate the wonderful 'metl' of that land. The importation may have been made very soon after the conquest of Mexico by Cortez, but I find no record concerning it. It is even questionable what species was actually first taken over. The first tangible record of an *Agave* in Europe is given by Clusius, a Belgian botanist who, traveling through Spain somewhat more than a generation after the conquest of Mexico, found an aloe of this kind sparingly cultivated at Valencia, where he obtained offsets which he took home, and one of which he figured in 1576. While this first picture probably represents *A. Americana*, as it is usually supposed to do, it must be admitted that it resembles also the common pulque maguey of the table-land, even then an important plant, but which is not known to have been in European gardens before the middle of the century just closed. In 1586 an American aloe flowered at Florence, and was figured by Camerarius two years later. This picture is less questionable than that of Clusius, as representing what we now call the century plant, but it might possibly stand for what, a century later, was grown in Dutch gardens as the broader-leaved aloe from Vera Cruz—now known as *Agave Vera Cruz* or the synonym *A. lurida*. The reported escape of the latter species in central Italy lends some support to this surmise; but the picture can not be said not to represent *A. Americana*, the wide-spread naturalization of which through the Mediterranean countries seems to indicate conclusively that, whichever may have been introduced first, it was really the century plant that was first extensively propagated in Europe.

FIG. 18. WILLING TO BE PHOTOGRAPHED.

The agaves have been esteemed as garden curiosities ever since their

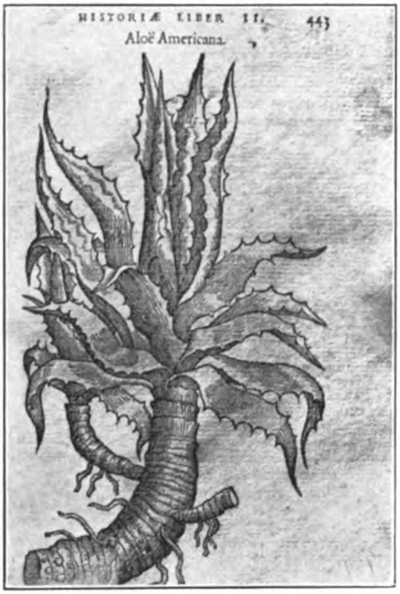


FIG. 19. THE FIRST PICTURE.

first introduction into the civilized world, and many of them are really beautiful plants; but while one of them has leaves only an inch long, the size of others is so great as to render them unsuitable for ordinary cultivation under glass, and really representative collections have been made by only a few amateurs and botanical gardens. About forty years ago a taste for growing some of the smaller species was fostered by Belgian dealers who successfully exhibited and advertised select specimens of new importation, some of which sold for very profitable sums; but I do not recall a single one of the private collections of a generation ago which is still kept up, though fortunately some of the better plants have found their way finally to Kew or some other botanical establishment.

FIG. 20. FIGURED BY CAMERARIAS.

Botanists have generally agreed to date their scientific naming of plants from 1753, when Linnæus substituted the convenient binomial for the awkward if usually terse description that had been used up to that time when reference was made to a plant. This date, consequently, begins the modern history of *Agave*, which, some years earlier, had been segregated from the African genus *Aloe*.

In his 'Species Plantarum,' published in that year, Linnæus describes only four species—one of which, the 'cabuja' of the tropical mainland, belongs to a sufficiently distinct genus, *Furcræa*, which was separated from *Agave* half a century later. One of the remaining three is the century plant, *A. Americana;* another is a characteristic large species of the Greater Antilles, *A. vivipara;* the other is an interesting little plant of our own flora, with thin leaves which die down every winter, and a slender raceme of flowers, *A. Virginica,* which is now made the type of a distinct genus, *Manfreda.* From the two Linnæan species left after the segregation of *Furcræa* and *Manfreda,* the genus *Agave* grew step by step, through later discoveries, to 127 species distinguished by its latest monographer. Of these, 35 belong to the candelabrum group designated as *Euagave* and represented by the two Linnæan species, and 46 have the flower-cluster contracted as in *A. Lecheguilla,* constituting the group *Littæa.* The inflorescence of the remaining 46 was not known when this monograph was written—nearly twenty years ago, and a very large part of the species have been known only through cultivated plants, most of which were described when immature, and of which no inconsiderable number died or were lost sight of before reaching a flowering age.

The describer of a garden species of *Agave* usually finds himself impelled to set down its probable habitat as Mexico. In this guess he is

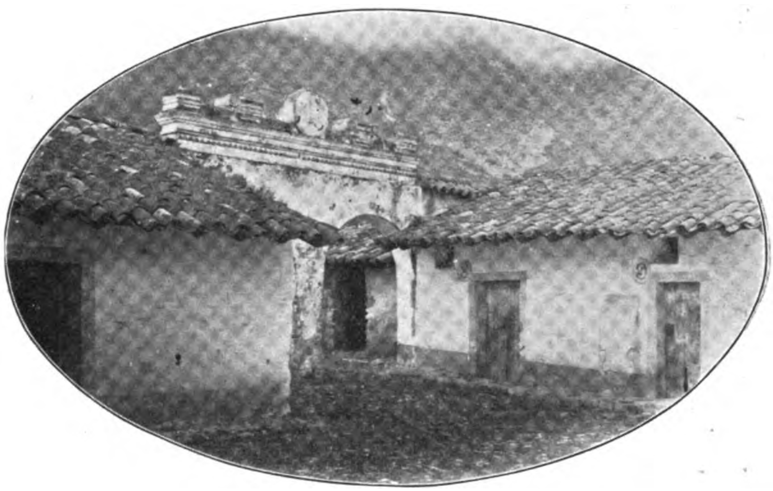


FIG. 21. HOTEL AT MALTRATA.

favored by the law of chance, for only a few agaves occur to the north or south of Mexico or in the West Indies; but a considerable number of intentional or chance hybrids have originated in gardens in addition to some apparently purely cultural forms, the numerous descriptions of the last two decades are widely scattered and little comparable, and the genus stands to-day as one of the worst confused of its size—the actual number of its species apparently being not far from 200.

There appears little hope of removing this confusion except by protracted field study under unusually difficult conditions, supplemented by garden cultivation of plants from definitely ascertained spontaneous sources. Serviceable herbarium specimens are rarely seen. Their preparation is unusually difficult because of the large size and succulent nature of the plants, but they can be made. The camera is as indispensable to the field student of these plants as the trowel or drying press, and the data used by whoever may succeed in adequately monographing the agaves will necessarily include habit pictures and full-size details, photographed on the spot.

Anything which takes one into the pure air and bright sunshine of the mountains brings in the enjoyment of these a full compensation for the inseparable hardships of travel in a sparsely settled country where the comforts of life are not to be looked for outside of the larger cities, and where one frequently goes to bed literally with the chickens or is stabled in the barnyard.

The agaves are preeminently plants of rocky places. Some of them delight in hanging from the sides of cliffs which are all but inaccessible. Others grow in the middle of the great fields of broken ragged lava to which the Mexicans have applied the expressive name 'malpays' or bad lands. Collecting under such conditions is scarcely capable of description without the unimpeachable evidence of the phonograph, which is not yet generally recognized as a necessary part of the botanist's equipment. I regret that while I have been able to show pictures giving some idea of the obstacles to travel in the barrancas and lava beds, of the altogether tantalizing places in which choice plants are seen, and of the difficulties attending the transportation of those that can be reached, I have no phonographic record fit for public demonstration.

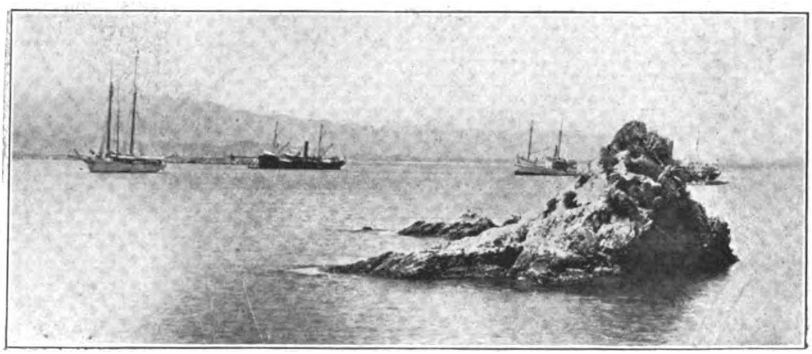


FIG. 22. WHERE CHOICE PLANTS ARE SEEN.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE. IV.

BY FRED DELAND

VII. SOME EARLY TELEPHONE SWITCHBOARDS

THE switchboards in the New Haven and other pioneer telephone exchanges were far more crude mechanically than the marvelous and sensitive hand telephone. The first switchboard that Mr. Coy installed in New Haven had a capacity of only eight lines, but as every line was a party-line, and as an average of twelve subscribers were on each line, the board served a hundred or more subscribers. This board was designed and built by Mr. Coy, in December, 1877, with the aid of a local carpenter, and formed a part of the partition

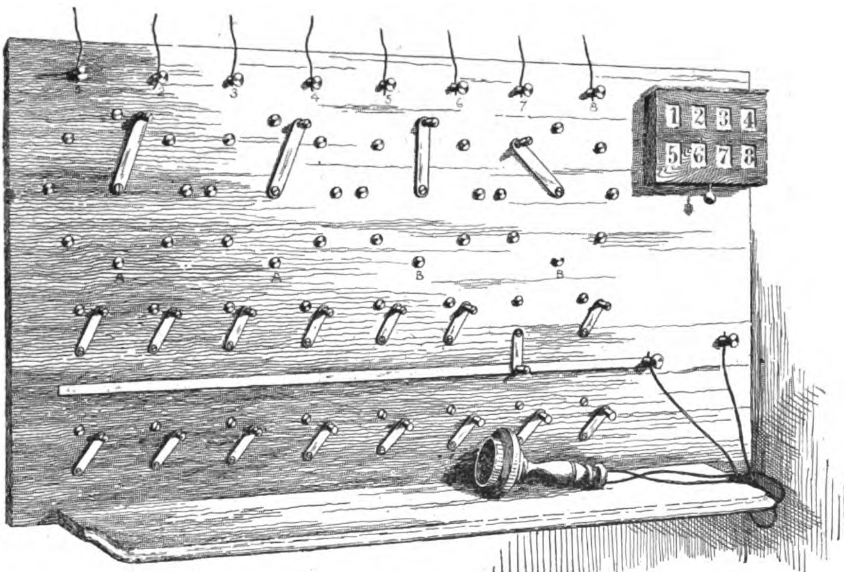


FIG. 6.

that separated the office from the battery-room. So far as known no photographs of the exchange or of the board were ever taken, and when the partition was removed the switchboard no longer existed. However, in Fig. 6 is an excellent reproduction of a rough sketch made from memory many years ago, of what Mr. Coy asserts was the first switchboard, though others claim that the board had no annunciator attached during the first two months.

Crude as the construction of the board was, without cords or plugs, clearing-out drops or other improvements that facilitate rapid service on the part of the operator, it was considered a remarkable piece of workmanship in its day, and prospective investors in telephone systems traveled from various states to inspect Mr. Coy's equipment and to study the working method of this first of all telephone exchanges. The switchboard used in the Meriden exchange, opened a few days after the New Haven exchange, is now preserved in the Smithsonian Institution at Washington. It is similar in type to the New Haven board, and was designed by Mr. Coy. The switchboard used in Richmond, Va., as late as April, 1879, had six dials on its face, 'each circle about ten inches in diameter, formed by thirty-nine numbers.'

Service from Mr. Coy's board was supplied after the following fashion. On the shelf was a large induction coil with a manually operated buzzing attachment (Fig. 7). This calling device was known

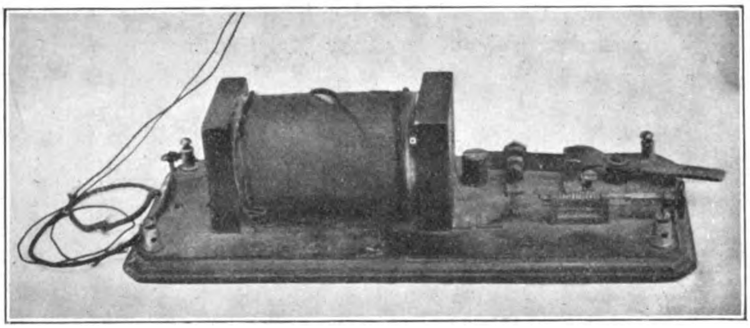


Fig. 7.

as 'Watson's squealer' and also as 'Coy's chicken,' for the shrill squeal it sent out over the line could be easily heard in all parts of a large room. When 'Central' desired to call a given subscriber on a party-line, as No. 5, for instance, on party-line No. 8, the operator connected this buzz-box to line No. 8 and sent five long squeals over the line, which would be the signal for subscriber No. 5 to come in on the line, and for the others to stay out.

For the use of his subscribers in New Haven, Mr. Coy hung the mahogany or rubber-encased hand telephone on a steel hook screwed into a black walnut board (Fig. 8) which he attached to the wall of the subscriber's room or office. Binding posts for wire connections were fastened to each corner of this board, with a simple strip type of lightning arrester connecting the upper two posts, line and ground. Near the center of this board and bridged on to the grounded iron telephone circuit, was a circuit-break push button for the subscriber to use in calling 'Central.' Below the push button was inscribed the number of the telephone.

Primitive as this outfit now appears, it was considered a luxury in 1878 that many were glad to have, and practically constituted the entire telephone equipment supplied to subscribers by the early telephone exchanges. For as rapidly as other operating companies came into existence, they copied or adopted Mr. Coy's equipment, modified more or less according to the mechanical or artistic views of the local manager or his manufacturer. A modification used in Richmond, Va., is shown in Fig. 9.

In one sense these magneto systems might be properly termed central-energy exchanges. For though no batteries were required to operate these pioneer hand telephones, all the current required to signal 'central' or 'subscriber' was supplied from a 'common-battery'

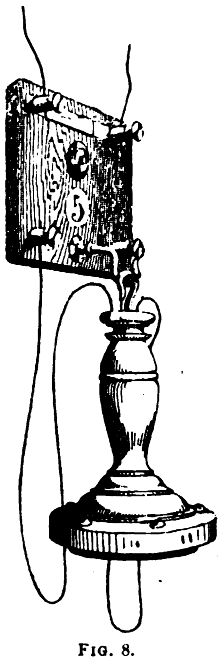


FIG. 8.

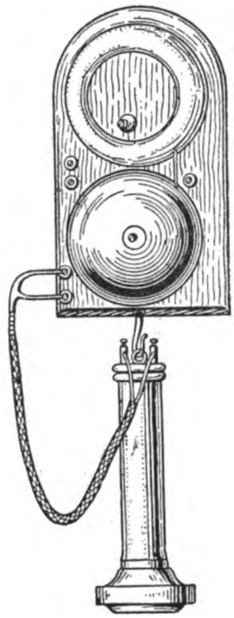


FIG. 9.

set of gravity cells maintained in the exchange and operating on a closed circuit.

When a subscriber desired 'Central,' he touched the metal push button, shown in Fig. 8, which actuated a single-stroke bell in the exchange and released a drop in the ordinary house-annunciator attached to the switchboard, thus indicating the respective party-line. On hearing the bell, the boy-operator would leave whatever other work he was engaged upon, walk leisurely over to the board, glance at the annunciator, turn the single switch to the metallic strip to bring his telephone in circuit with the calling subscriber, and loudly enquire: 'What do you want?' then place his telephone to his ear just too late to catch the full reply. Louder explanations on both sides would follow, and sometimes the subscriber's remarks were not of a character suitable for publication, while the replies of the operator partook of the same lurid nature. For there were no sissy-boys and no girls among the pioneer operators of 1878–1880.

Finally, subscriber No. 5 would make the operator understand whom he desired to be connected with. Then the connection was given by turning the lever of one circle to the peg to which the calling-line was attached (Fig. 6), and placing the lever of the other circle on the peg or post connected to the line of the calling subscriber. The boy would then go back to his other work and probably forget all about the two subscriber-lines connected together, until an infuriated individual would rush into the office and demand the reason why some blithering idiot failed to answer his bell. Then the boy would have to pacify the subscriber as best he could by explaining that when two subscriber-lines were connected together, the call-bell and the battery-connection on each line were cut out to improve the talking qualities, and each subscriber was connected straight through to each other's telephone;

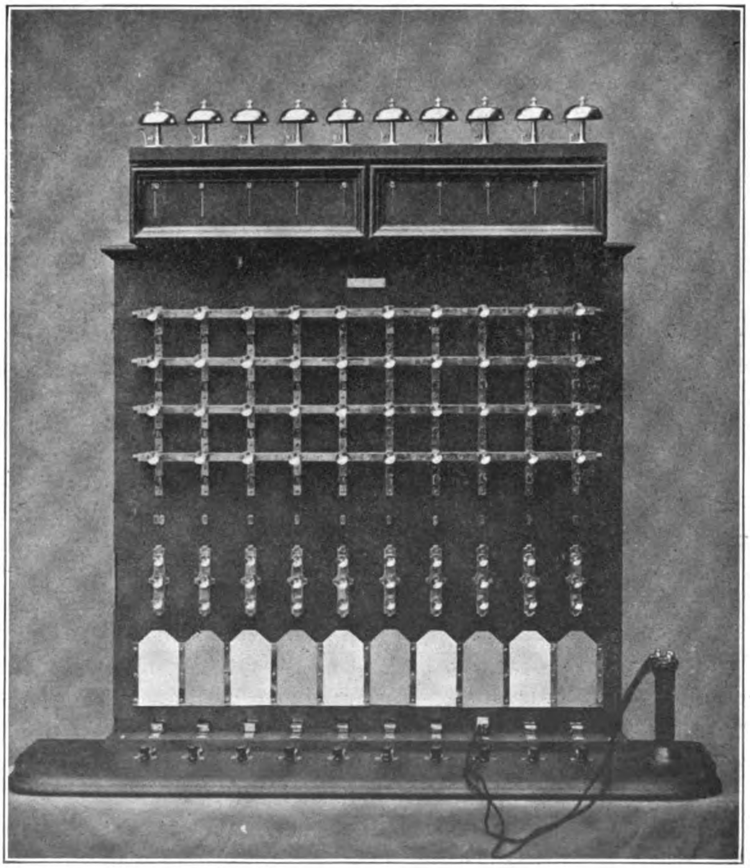


FIG. 10.

that in the pressure of cleaning batteries, or sweeping the room or doing some other kind of work, boy-like he forgot to disconnect the circuits.

With Mr. Coy's first board two telephonic connections only were possible at the same time. That is, two conversations only could be carried on at the same time. If a third subscriber desired connection, it was necessary to await the release of a lever by the disconnection of one of the other lines. Then the bright thought occurred to the boy-operator that by wetting the tips of his fingers and placing them on the respective pegs, his arms would become the levers of the respective circles, and thus the two subscribers could talk through his body. This very ingenious makeshift served to tide over the brief period during which an addition of two more circles was made to the original board, thus increasing its capacity fifty per cent. But one day, while the boy-operator was letting his wet finger-tips perform the service, now taken care of by cords and plugs, the ring-off signal came in from a subscriber who had just had a powerful magneto installed, and the shock received ended that very convenient practice.

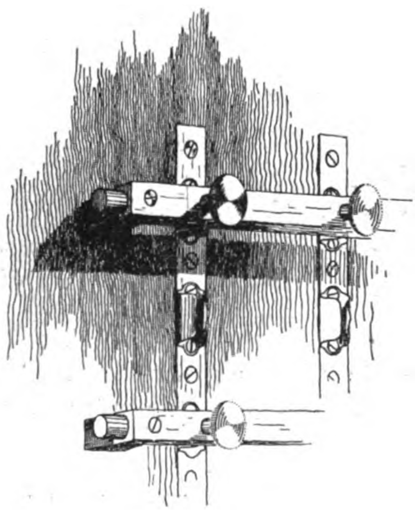


FIG. 11.

Soon there were more than 150 subscribers on twelve subscriber-lines, and the ratio of calls per subscriber was constantly on the increase. So a new board was planned by Mr. Coy and built by Mr. Snell, who is still in New Haven engaged in supplying equipment-specialties to telephone companies. This board (Fig. 10) had a line capacity of forty wires. Evidently switchboards of this type found favor for a time in the opinion of the parent company; for a circular issued in 1880, by the National Bell Telephone Company, contains the following suggestions, all of which were omitted from a circular of similar purport, issued a year later by the American Bell Telephone Company:

There are several styles of switchboards that may be used, all depending on the general principles for tneir operation. They consist essentially of horizontal and vertical bars crossing one another and arranged so that any horizontal bar can be connected to any vertical bar. It is chiefly in the methods of making the connection that the various switches differ. In what is known as the 'plug' switch, the connection is made by inserting a small metal plug at the point where the horizontal and vertical bars cross one another. There are several forms of the plug switch. . . . In what is known as the slide central office switch, the connections are made by means of a sliding contact plug, which can be moved on the vertical bars, and when placed over one of the horizontal bars, springs into firm contact with it . . . (as shown in Fig. 11). The brass rods for connecting any two lines together are fastened to the walnut frame, and in front of them but not touching, are the upright rods. The line circuits, as they enter the office, are connected to the upright rods by binding screws on top of the frame. Each of the upright rods has a spring-slide which, when pulled outward, can be slid freely on the rod, and which, on being released, springs into firm contact with any one of the horizontal rods with which it may be desired to connect it.

Within a year the increase in the number of subscriber-lines in the New Haven exchange made an additional board necessary. So a Snell board having a capacity for thirty-five subscriber-lines was in-

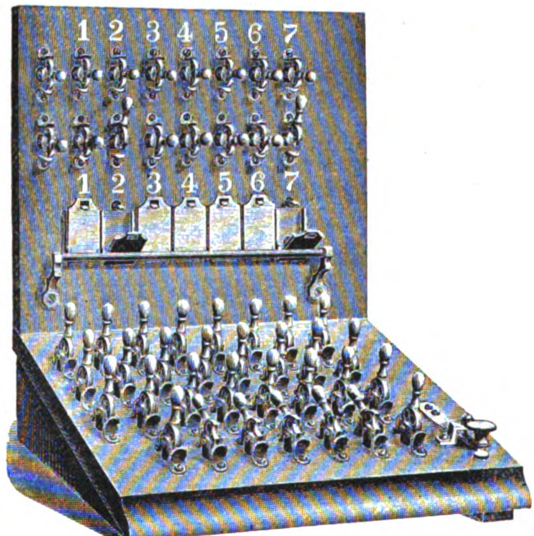


FIG. 12.

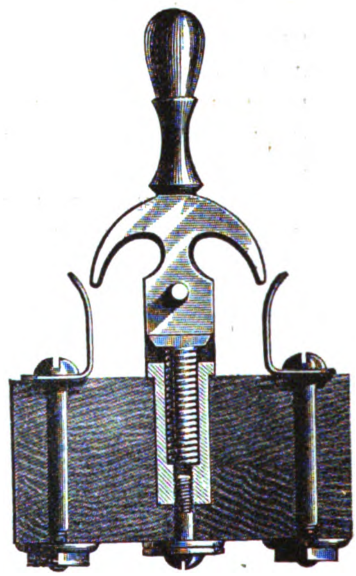


FIG. 13

stalled and connected to the old board. The principal feature of the Snell board (Fig. 12) is the Snell jack (Fig. 13). The instructions sent with the board read:

The line connects the levers together perpendicularly. The springs being connected horizontally, form the connecting bars. Any two circuits are connected by throwing the corresponding levers on the same row of springs. We have testimonials from parties using the switch, where one operator does all the work satisfactorily for *three hundred subscribers,* where with any other system it would require at least two, thus making a permanent saving in the running expenses.

A cheaper type of Snell switchboard is shown in Fig. 14, using what are called 'tip-up jacks.' This board consisted of an

inclined table, having as many grooves, about a quarter of an inch wide and deep, as may be required for connecting bars. Between every third groove is a row of counter-sunk holes for the wire posts inside of a spiral spring; a smaller wire passing through the ends of the posts forms the line and acts as a hinge for the little tip-up jacks, that connect the line with the brass plate on the bottom of the groove. The spring allows the post to give a little, thereby making a rubbing connection and holding the jacks firmly in their place when any two are tipped up on the same groove to make connections.

The combined annunciator recording drop-plate shown on this Snell board is of interest in showing the appreciation in those pioneer days of the necessity of a measured-service system. Five falls of the plate (Fig. 14) would cause one revolution of the shaft, which, in turn, would move the indicating wheel one notch. A later form of switch-

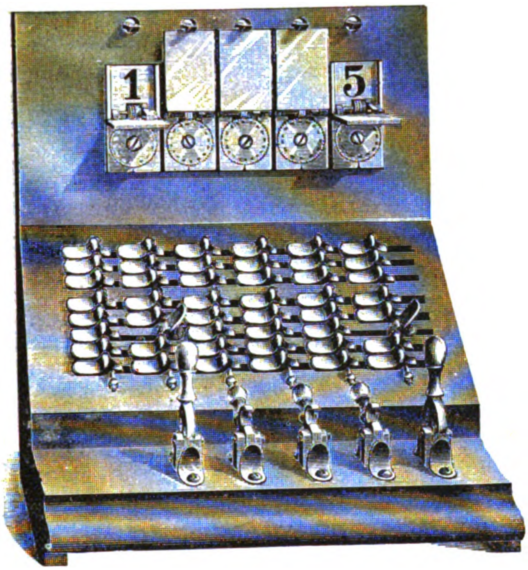


FIG. 14.

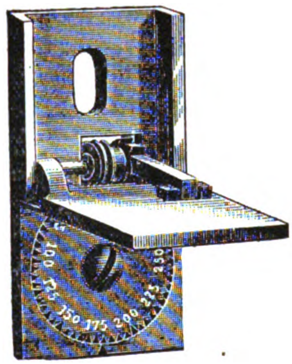


FIG. 15.

board devised by Coy and Snell is shown in Fig. 16. A board of this type was installed in Hartford in 1879. In December, 1881, in the Providence exchange there were thirteen Post-Snell switchboards of twenty-five wires each, four of fifty wires and one of sixty wires, arranged on three sides of the operating room, and from these eighteen boards service was supplied to eleven hundred subscribers.

The switchboards adopted by other exchanges were as unique in character as those erected in New Haven. In St. Louis, in April, 1878, Mr. George F. Durant used a 'jump jack switchboard,' the operation of which is thus described:

On the subscriber ringing his bell, the annunciator would fall and the boy-operator would ask: 'What do you want?' Finding out what was wanted, the boy would notify the switchman what connection was desired, which was made by two single plugs attached to a single cord, by placing one of the plugs under each of the jacks requiring the connection.

The second switchboard had brass bars running the entire length of the board, with holes about every five or six inches to insert the plugs

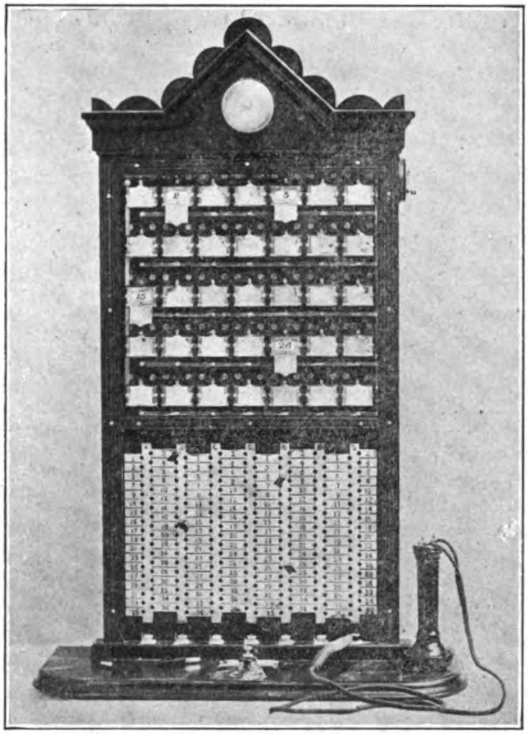


FIG. 16.

into, and were connected to the disconnecting switch through an indicator and jump jack.

In July, 1878, Thomas B. Doolittle planned and had constructed by Charles Williams, Jr., of Court Street, Boston, a twenty-circuit telephone switchboard, which Mr. Williams has stated 'was the first switchboard completely equipped with signaling apparatus ever made at my establishment.' This board (Fig. 17) was placed in Mr. Doolittle's exchange at Bridgeport, Connecticut, which succeeded to the first mutual telephone exchange system, and is the small board shown in Fig. 18.

In 1877, Mr. Doolittle had made a small six-point cross-bar switchboard for use in Bridgeport, in which he substituted simple switches for the usual telegraph plugs, as the former were more easily manipulated in making connections. Then he brought out the small board above referred to. Meanwhile he devised his 'direct-connecting board' (Fig. 18) in which each line terminated in the board after passing through a single stroke bell, to the hammer of which was attached a hollow brass ball suspended by a silk thread. To each circuit an operator's telephone was attached, and the cords were of sufficient length to reach the furthermost limit of the board. Following a subscriber's call the stroke of the bell set the brass ball to swinging, thus notifying the operator, who cut off the battery by turning a switch and then inserted a plug in the line socket and received the call. The companion cord was then removed from the ground plate and inserted in the socket of the line called for. Mr. Doolittle states that on several occasions he saw the operator take care of four calls at the same time by holding two telephones in the fingers of each hand, that is, the operator had to talk and then listen into four separate telephones; in other words, using both ears as well as both hands. Incidentally it may be mentioned that Mr. Doolittle claims that it was on this board that the first female telephone operator was employed. A glance at the illustration shows that the cylindrical wooden weights suspended on the plug cords were about an inch in diameter and a foot in length, with a brass pulley attached to the top of each. These long weights were employed at first in anticipation that their length would prevent the cords from swinging and tangling, but later were displaced by smaller but heavier lead weights.

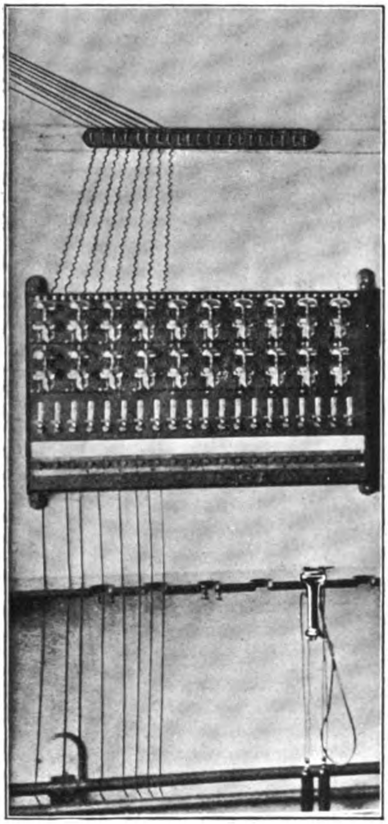


FIG. 17.

According to a local paper the switchboard erected in Philadelphia, in December, 1878, consisted of

a walnut frame and braced strips of brass punctured with holes, into which wires are fitted to make the necessary connections. Behind this all the wires converging in the office concentrate. The board accommodates 400 different lines.

In October, 1878, the parent 'Bell Telephone Company' issued a circular describing a form of brass strip switchboard 'adapted for six circuits.' On February 20, 1879, a circular was issued describing a switchboard which could be supplied at

from 50 cents to $1 per circuit, according to the number of circuits. The dimensions of this switchboard for from 50 to 200 circuits are 6 feet long by about 3 feet wide.

Switchboard tap-bells were listed at $2.50 each; subscriber's hook district bells, $3.25 each; spring keys, 75 cents each; lightning arresters, 37 cents per circuit. It was stated that "the following plan it is

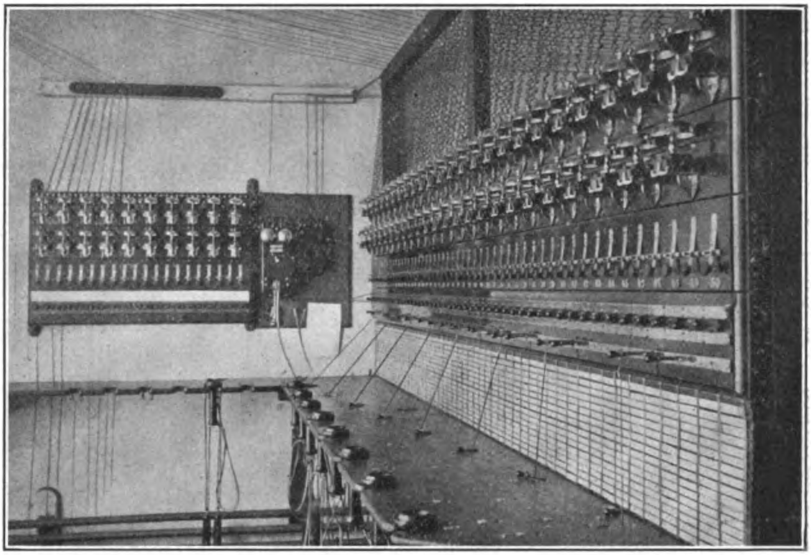


Fig. 18.

believed combines the advantages of the (thirteen) different systems." A diagrammatic representation of the wiring of a single circuit in this board is shown in Fig. 19. There is also shown a flexible cord attached to a plug and a wedge of hard wood having a metal plate fastened to one side. The instructions sent with the board read:

The local size gravity battery is used—one cell for each bell and for each mile of wire is sufficient. A circuit one mile long having ten bells requires about fourteen cells of battery. Two circuits may be operated by one battery if they are about equal length and have the same number of bells on each. . . . When any subscriber on this circuit wishes to call the central office he presses his knob twice, which rings the bell; the operator then inserts the wedge between the spring and the plate, with the metal side against the spring, and the plug into a brass strip which is connected through a set of telephones to the ground. This, it will be seen, takes off the battery and connects the telephones so that the operator can talk with the subscriber and ascertain his wants. If the subscriber wants to talk with a person on another circuit, the central office calls that person and on receiving his answer, the two circuits are connected together by inserting a wedge under each spring and putting each plug into one of a pair of brass strips which are connected together through a hand telephone by means of which the central office operator can ascertain when the two persons have finished using the circuits. Then he removes the wedges and plugs and the circuits are ready for another call.

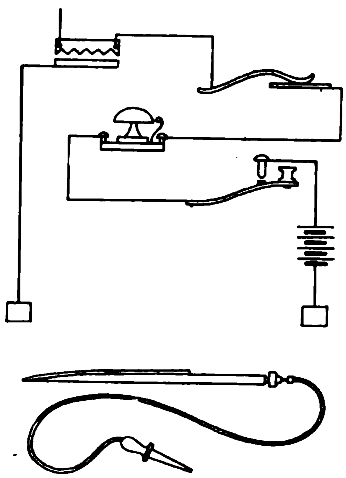


Fig. 19.

The instructions for the subscriber's equipment read:

The circuits are run from the central office and grounded at the last

> stations. A small electric bell is placed in each subscriber's house or office, having a hook projecting from its base on which the hand telephone is hung when not in use (Fig. 20). When the telephone is removed this hook can be thrown either to the right or left. When thrown to the right the line wire on one side of the station is connected through the telephones to the ground and the line on the other side is opened, preventing any one on that side hearing what is said. When thrown to the left the reverse is true. It is obvious that no person between the two that are conversing can put his telephone in circuit without breaking the line, and consequently, interrupting the conversation. All other stations on the circuit are notified that the line is being used by the striker being away from the bell. In this case the subscriber must not attempt to call or use the telephone. The signaling is done by pressing and releasing a knob the requisite number of times. . . .

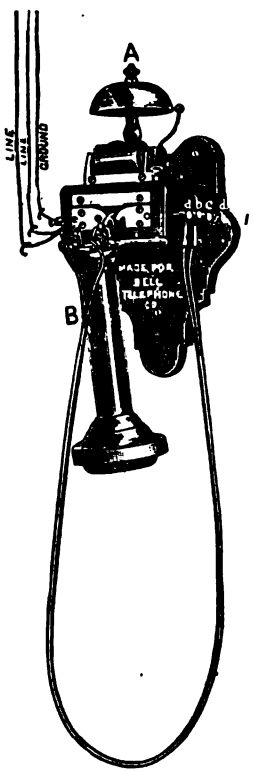


Fig. 20.

On June 12, 1879, the parent Bell company sent out photographs and a circular describing 'our No. 1 standard central office strip switch arranged for seventy-five circuits.'

In November, 1881, Mr. T. D. Lockwood said:

> To make a good telephone exchange switchboard, however, out of an ordinary telegraph switch, we concede that considerable remodelling is necessary; and after the first heat of invention was over, practical men began to look about them, to see the disadvantages they were laboring under and endeavor to overcome them. It was seen that time and money were, in telephone offices, the two main articles to be economized. Time, because speed of connection is the very life-blood of the business. Money, because in many of the exchanges the telephone business was managed and owned by men of little or no capital; and, in others, the expense, in any case, would be great, and economy was necessary to make anything at all out of the business. Soon, therefore, it became obvious that the telephone switch must be compact; all the apparatus must be easily and quickly under control; everything about it must be well made and well put together; the motions required in a connection must be reduced to a minimum, and yet the apparatus must be cheap. The cry of cheapness for a long time obscured the vision of the practical man.

In 1881 came the first of the multiple switchboards. This innovation was arranged for grounded and later for metallic circuits, and was designed to eliminate many of the causes tending to slow down the service. Under the previous system each operator was compelled to act as information bureau, and subscribers called by name rather than by number. The introduction of the mutiple board made necessary the assignment of numbers to subscribers, and many an urgent request to call by number rather than by name. Thus the multiple-board operator made connections only in response to requests giving numbers. If complaints were made or information requested, the caller was quickly switched to the information desk presided over by a special operator. In the same manner the toll calls were handled at a toll board or special section of the large board. A 1,500-line multiple switchboard was installed in New York in November, 1883.

In 1883 Mr. W. D. Sargent said:

The ideal (switchboard) system would be one in which the operator would receive the orders to connect and disconnect from the subscriber orally, by means of a head telephone; to have in front of her a switchboard by which she could connect any two wires of the whole system, however large, without interfering with the other operators. The nearest approach to this perfect system at the present time is the multiple-board; but this has never been worked on the true or multiple principle, and it can never show all its merits until it is. The multiple-board is now being introduced into many of the largest cities, and we may expect much information during the coming year on its merits.

Now-a-days a new switchboard is often placed in service so quietly that the subscribers are rarely aware of any change taking place until after the work is completed. But in the pioneer days it was somewhat different, as is shown in the following interview clipped from an eastern paper in 1882:

In removing from the old to the new central exchange unforeseen difficulties were encountered, chiefly in the removal of such a mess of wires and the abrupt change from the old system to the new system (of calling), and the

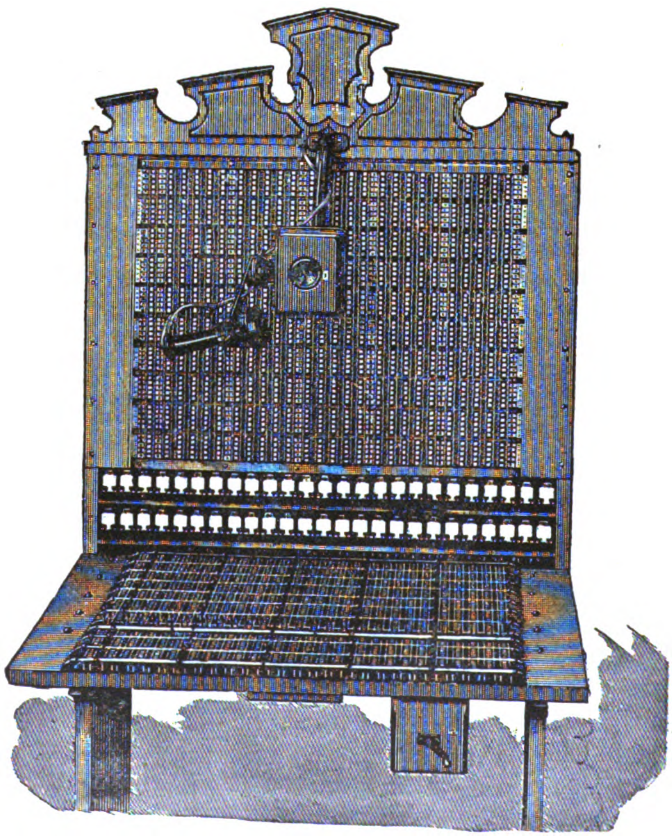


FIG. 21.

necessarily temporary character of much of the construction. The public had to be personally taught to use the new system, and our operators had to be educated in its rapid use. This naturally caused dissatisfaction, and before the system was tried and the construction trouble was eliminated, our subscribers, through misapprehension of the real purpose of the change, were invited to meet and form an association to protect their interests and compel satisfactory and perfect service on our part. . . . The association was soon compelled to acknowledge the superiority of the new service over that of the old.

In March, 1883, there were thirty Gilliland switchboards (Fig. 21) in the Pearl Street telephone exchange in Boston, and seventy-five toll lines terminated there. These boards stood about a foot apart and were displaced by a given number of multiple sections forming one compact, continuous board. In referring to the installation of the multiple switchboard in this exchange in 1884, Mr. Carty stated that

there were about 1,650 subscribers, ninety branch and thirty extra-territorial lines. The extra-territorial lines were handled by five operators on the 25-wire boards, on each of which there were a dozen or more subscribers. This called for a force of thirty-nine operators on tables at any one time, seven operators for relief and seven night operators, making a total force of fifty-three. With the multiple system only twenty operators are required to fill the boards in the main exchange, with five relief and four night operators. In the toll room, eleven operators are required, including the chief, one relief and two night operators. This makes a total of forty operators, handling 1,700 subscribers, 152 trunk lines, and shows a saving of thirteen operators.

Incidentally, it may be added that the Boston board was put in at an expense of $48,000. The old boards cost over $20,000, but brought less than one tenth that sum when sold as junk, though in use less than four years, and some less than two years.

In September, 1885, Mr. T. D. Lockwood suggested that where the multiple board was to be installed it would be well

to get the numbers drilled into the subscribers first. I was in Baltimore eighteen months ago, when the subscribers were all known by name. They were going to change that, and they were also introducing the multiple boards at the same time; and the operation of the new multiple boards was somewhat premature, because the old boards fell to pieces about a week before the new ones were expected and the change had to be made very quickly, and the change from names to numbers, and from the old board to the multiple board resulted in producing a condition of things very like a pandemonium for three or four days.

That the Western Union's competitive telephone service was of no better character than that of the Bell, notwithstanding its long experience in serving the public and the far greater resources at its command, is clearly portrayed in a description by a *Times* reporter, of a visit to the Chicago exchange of the American District Telegraph Company, in July, 1879. He wrote:

The racket is almost deafening. There are speaking tubes running all about the room, which look not unlike small stovepipes, and at one end and the other of these are placed the lips of one operator and the ear of another. Boys and girls are rushing madly hither and thither, seemingly without intent or direction; while others are putting in and taking out pegs from the metallic surface of the central framework or switchboard as if they were lunatics engaged in an old-fashioned game of fox and geese.

How different are present-day conditions in the large exchanges, where the operating force is well disciplined and thoroughly trained, and where the modern relay multiple switchboard affords every facility for rapid intercommunication. So compact are these improved switchboards that each subscriber-line reappears in each and every section, thus enabling any one of the three operators allotted to a section to reach the jack connecting with the subscriber line of any one of the many subscribers connected to that given exchange even though they number ten thousand. Under these favorable conditions the average time in which 'Central' answers a calling subscriber rarely exceeds four seconds, and a local call is completed on an average of less than thirty-five seconds, the time consumed depending largely on the promptness with which the called subscriber responds to 'Central's' calling.

Concerning the rapidity with which telephone connections were secured in pioneer days, we have a statement made in 1887, by Mr. B. E. Sunny, a man of exceptional ability, who was one of the first to comprehend the true function of telephone service and who strove to make his service the best that human effort and improved apparatus could make it. Mr. Sunny said:

> Chicago has tried the division of labor plan on three distinct types of switchboard. On the first switchboard in the central office in about 1880, with four hundred subscribers, we were able to make a connection in about five minutes; on the second type of switchboard, which was the Gilliland, we were able to make connection with five operators in about two minutes. On the third type of switchboard, which was the Western Electric pattern, but of special make, we came mighty near not being able to make any connection at all; but after we had hammered away at it for a long time, we got the time down to about two minutes and a half. We changed from that to our present system of the unit of labor, and we make connections on an average of about forty-five seconds. So far as possible we make two operators on all connections, local and trunk, do the work.

It is also interesting to note that in 1884 Mr. Sunny started a school of instruction for telephone operators in Chicago. When an applicant appeared she was advised to enter this school and receive free instruction, and about one in four of the students were found competent to enter the regular service. When full, the class was composed of ten students. The teacher in charge was a former public school teacher, who had also served four years as an operator, monitor, chief operator, etc., under conditions that had enabled her to gain a thorough knowledge of the duties of an operator. The school apparatus consisted of three sections of switchboard and a dozen or more telephones connected up at different points in the school-room. Calls were sent in and connections made at the switchboards as nearly as possible according to regular practice. Mr. Sunny found that this method of training

> educates the students in the matter of hearing and talking and handling the cords and handling the cam-levers, so that when they sit down to actual work they have nothing to overcome except the momentary nervousness. In the old system we used to take a new-comer and put her on a section to answer fifty subscribers, and we used to depend upon the subscribers to educate the operator and make her competent to fill that position.

DENATURED ALCOHOL

BY PROFESSOR S. LAWRENCE BIGELOW
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WIDESPREAD interest was aroused by the passage, last June, of an act of congress permitting the manufacture and sale of alcohol tax-free after January 1, 1907, provided it be rendered unfit to drink by the addition of substances imparting to it a repulsive odor and taste. Such alcohol is known as denaturalized, denaturized, or denatured alcohol, and the substances added are called denaturizing or denaturing agents, or more simply, denaturants. These are barbarous terms, almost as repulsive as the substances themselves. It is only fair to add that neither Professor Matthews nor President Roosevelt is responsible for these dislocations of our language. They are literal translations from German and French equivalents. True to its resolutions of reform, our government has adopted the simplest of these terms and recent publications refer to denatured alcohol and denaturants.

The cause of the general interest in the subject is twofold. Each individual in the community has reason to think that he may perhaps derive some benefit from this bill; that he will be able to use denatured alcohol in a way to increase his comforts or to diminish his running expenses. A smaller number see in the new article of commerce possibilities of profitable occupation or of profitable investment. It is my purpose to consider certain facts regarding denatured alcohol which have a bearing upon these expectations.

Alcohol, to the chemist, is a class name for a large number of different compounds, all of which have certain definite characteristics in common. The proper name for 'ordinary alcohol,' sometimes called 'grain' alcohol, or 'spirits of wine,' constituting between 40 per cent. and 55 per cent. of the volume of whiskey, brandy and the other so-called spirituous liquors, 8 per cent. to 25 per cent. of the volume of wines, 3 per cent. to 8 per cent. of the volume of beers and ales, is ethyl alcohol. It contains only the elements carbon, hydrogen and oxygen. Its chemical formula is C_2H_5OH and it is the only 'alcohol' which can be taken as a beverage, all others being much more poisonous. For instance, wood alcohol, the correct name for which is methyl alcohol, a substance about which we shall have frequent occasion to speak as it is to be one of the denaturants, is closely related to ethyl alcohol, containing the same elements only in slightly different proportions. This is clearly shown by its chemical formula, CH_3OH. But it is a dangerous poison, and numerous cases are on record of deaths due to its being mistaken for ethyl alcohol. This mistake occurs easily. A man asked a druggist for a bottle of good alcohol. The druggist understood him to say wood alcohol. The customer took his purchase home, drank it and died. Moreover, there is something particularly horrible about the action of wood alcohol. Numerous instances are on record proving that the substance has a specific effect on the optic nerve. After complete recovery from dangerous doses of methyl alcohol, in the course of a few days, patients have become totally blind. It is desirable that these facts should be as widely known as possible, since denatured alcohol is required by law to contain 10 per cent. of this poison.

It is not too much to say that if we arrange all the liquids known to us in the order of their general usefulness, water, which heads the list of course, will be followed immediately by ethyl alcohol. Ethyl alcohol is colorless and of an agreeable odor. It is an admirable cleaning agent, and a good antiseptic and disinfectant as well. It is an ideal source of heat and power and is capable of being developed into an ideal source of light. Ideal, because the products of its combustion, carbon dioxide and water, both of which are normally present in the air, are quite odorless and are harmless; ideal because, evaporating quickly and completely if spilled, it is much cleaner than any oil. It is an indispensable solvent in many chemical industries and is the raw material from which important substances, such as acetic acid (vinegar), the anesthetics ethyl ether and chloroform, the antiseptic iodoform, and many other substances are made. It is the cheapest and easiest of all the alcohols to manufacture.

Truly, it is unfortunate that to this list of advantages must be added the fact that it is drinkable, for this last property is made to justify so many restrictions that its application to these useful purposes is badly hampered. Alcoholic beverages are generally acknowledged to be unnecessary luxuries; therefore, by common consent, they are heavily taxed in every civilized country. A quantity of alcohol costing about 11 cents to make, namely, a 'proof' or 'tax' gallon, pays an internal revenue tax of $1.10. The 'proof' or 'tax' gallon contains about 50 per cent. by volume of ethyl alcohol, and about 50 per cent. water. The law reads in such a way that if the alcohol happens to be stronger, or above 'proof' as it is called, the number of gallons of 'proof' spirit which could be made from it is calculated and the tax is paid on this computed quantity. But, on the other hand, if the alcohol be weaker, *i. e.*, below 'proof,' it is taxed as if it were 'proof.'

This term 'proof spirit' had a somewhat curious origin which is at the same time illustrative of the absurdly unscientific nature of many of our commercial units of measurement. Formerly, in England, a little pile of gunpowder was made and the 'spirit' to be tested was poured over this and lighted. If the burning alcohol, before going out, set fire to the powder it was said to be above proof; if it went out without igniting the powder, it was said to be below proof. Thus 'proof spirit' was defined as the most dilute alcohol which would set fire to gunpowder under these conditions. The ridiculous inaccuracy of such a test is sufficiently apparent. The British parliament and our congress both passed laws defining 'proof' in terms of specific gravity.[1] The alcohol which we buy for use in alcohol lamps or for

[1] "'Proof spirit' . . . was defined by act of Parliament to be such that at 51° F. (10° C.) thirteen volumes shall weigh the same as twelve volumes of distilled water. The 'proof spirit' so made will have a specific gravity of 0.91984 at 15.5° C. (60° F.) and contain, according to Townes, 49.24 per cent. by weight of alcohol and 50.76 per cent. of water. Spirits weaker than proof are described as U. P. (under proof), stronger than proof as O. P. (over proof); thus a spirit of fifty U. P. means fifty water and fifty proof spirit, while fifty O. P. means that the alcohol is of such strength that to every one hundred of the spirit fifty of water would have to be added to reduce it to proof strength."—'Handbook of Industrial Organic Chemistry,' by S. P. Sadler, p. 217.

"Proof spirit is alcohol of such a strength that 13 gallons of the spirit have the same weight as 12 gallons of distilled water at 10° C. Proof spirit contains 49.24 per cent. of absolute alcohol by weight."—'Outlines of Industrial Chemistry,' Thorpe, p. 409.

In the *Zeitschrift für angewandte Chemie*, Vol. I. (1888), p. 29, may be found tables for the conversion of per cents. over and per cents. under proof into per cent. of alcohol by volume. According to these, for instance,

1 per cent. over proof equals 57.8 per cent. alcohol by volume
70 per cent. over proof equals 97.3 per cent. alcohol by volume

that is, 100 per cent., or absolute alcohol, beyond which we can not go, corresponds to a little less than 75 over proof. According to these tables again,

1 per cent. under proof equals 56.6 per cent. alcohol by volume
70 per cent. under proof equals 17.2 per cent. alcohol by volume

that is, pure water, containing no alcohol, is 100 below proof. The above figures show 'proof spirit' as containing about 57.2 per cent. alcohol by volume.

The above definitions apply in England, but not in the United States. Section 3,249 of the Internal Revenue Laws in force January 1, 1900 (page 144) reads: "Proof spirit shall be held to be that alcoholic liquor which contains one half its volume of alcohol of a specific gravity of seven thousand nine hundred and thirty-nine ten thousandths (0.7939) at sixty degrees Fahrenheit."

The following dialogue appears in the hearings before the Committee on Ways and Means, February–March, 1906, on page 121:

Mr. Boutell: "In that connection will you kindly explain the use of the word 'proof' in connection with alcohol? Absolute alcohol would be what proof?"

Professor Wiley: "It would be 200. That is, a commercial gallon of pure alcohol would be 200 proof."

Mr. Boutell: "And a gallon of it on which a tax of a dollar and ten cents is levied is 100 proof?"

rub-downs is much stronger, averaging 85 per cent. or 90 per cent. Investigations carried out in Germany have demonstrated that the best strength for general, miscellaneous uses is 95 per cent. and that is the strength which we, as consumers, should insist upon.

It is readily figured out that such alcohol at the present time must pay a tax of $2.08 the measured gallon. The wholesale price is in the neighborhood of $2.50 per gallon, of which we may estimate the government gets $2.08, the distilleries 42 cents.

The tax on alcohol yields a not inconsiderable fraction of the whole revenue of the federal government. According to the 'Statistical Abstract' for 1904, published by the government, the Internal Revenue collections were as follows:

Year.	From Spirituous Liquors.	From Fermented Liquors.	Totals.
1900	$109,868,817	$73,550,755	$183,419,572
1901	116,027,980	75,669,908	191,697,888
1902	121,138,013	71,988,902	192,126,915
1903	131,953,472	47,547,856[3]	179,501,328
1904	135,810,015	49,083,458	184,893,473

The federal government has no disciplinary motive in this heavy tax; that function is performed by the individual states and cities under the familiar name of local option. The government merely takes advantage of the strong feelings of so many individuals against the use of alcoholic beverages at all to levy a tremendous tax. It is an interesting fact in this connection that no increase in the tax has ever produced an appreciable diminution in the amount consumed in this or in any other country.

The demands of manufacturers and others desiring to utilize alcohol for economic purposes were recognized long ago by other governments, and the efforts to satisfy these legitimate demands, while at

Professor Wiley: "Yes; it is called 'proof' simply. That means 100 proof."

Mr. Boutell: "It means one half of absolute alcohol and one half of H_2O?"

Professor Wiley: "Yes, that is what it means. This cologne spirit is about 96 per cent., and the rest of it is water. . . . This would be then 192 proof, or 92 above proof, as it is very commonly expressed. It is a purely arbitrary method of statement, fixed for the convenience of our excise office. When they say liquor is 'proof,' it means that it is one half ethyl alcohol and one half something else."

On page 154 of the same hearings:

Mr. Stevens: ". . . ordinary alcohol is 188 proof. You divide that by two and it gives you 94. You divide the proof by 2 and it gives you the percentage."

As Thorpe's and Sadler's books are so widely used as texts and as references, it is safe to assume that there is a little confusion as to the meaning of this term 'proof.' It should be made clear that there is this difference between the English and the American definitions.

[3] The war tax was removed from beer.

the same time safeguarding the revenues, resulted in this ingenious scheme of 'denaturing.' We are fifteen or twenty years behind Germany, France[3] and practically all other civilized countries with our recent measure. It is very evident, then, that there is nothing new about denatured alcohol. Our tardiness brings one advantage, however; we may profit by the experience of others. Some of this experience and some of the more important known facts may be considered conveniently under the three heads: the manufacture of alcohol; denaturants; and uses of denatured alcohol.

The Manufacture of Alcohol

The fact that alcohol results from the fermentation of sugar by means of yeast is well known. Cane or beet sugar, the chemical name for which is sucrose, is first broken up into a mixture of glucose and fructose. This mixture is known as invert-sugar, referring to optical properties which it would take too long to describe. This 'inversion' is produced by a substance called invertase present in the yeast. It may also be accomplished by the action of dilute acids. The glucose and fructose then undergo fermentation, a splitting up into ethyl alcohol and carbon dioxide, as a result of the growth of the yeast plant. Pasteur's long and brilliant investigations led him to believe that fermentation could never occur except when accompanying some kind of multiplication of cells, either yeast cells or bacteria, *i. e.,* some form of living protoplasm, and that it was thus a physiological phenomenon. By means of great pressures, Buchner, however, succeeded in extracting from yeast a liquid which contained no cells and no living protoplasm and yet produced fermentation. The German name for this liquid is *Presssaft,* which may be translated into 'press-fluid.' The fermentation is produced by a substance, which Buchner called zymase, in solution in this 'press-fluid.' Since then numerous other similar substances have been discovered which produce chemical changes, formerly supposed to occur only in conjunction with life processes. These substances, the inorganic or 'cell-less' ferments, of which invertase and zymase are typical, are known as enzymes. We really know very little about these enzymes or how they work, but they are intensely interesting and many of the ablest scientists of the times are engaged in their study.

Glucose and fructose are but two of a large number of chemically similar bodies which can be obtained from a great variety of agricultural products such as corn, rye, grains of all kinds, apples, grapes and fruits of all kinds, from Irish potatoes and from sweet potatoes, in short, from anything containing either starch or sugar. A list of

[3] In France, the first law relieving from taxes alcohol intended for industrial purposes was passed in 1814.

the names given to these substances would be superfluous; in the language of chemistry they are all sugars, though they are not all sweet. Differing in minor particulars, they all have certain properties in common, and the most characteristic of these common properties is that they each and all may be fermented and will yield ethyl alcohol as one of the products of the fermentation.

The methods for conducting the fermentation on an industrial scale have been carefully worked out, but it is not the intention to enter here into the details of that phase of the subject.[4]

Ethyl alcohol boils at a lower temperature than water, consequently when the dilute alcohol obtained by fermentation is subject to distillation the distillate contains more alcohol and less water than the original liquid. When the alcohol has been concentrated by distillation to about 40 per cent. or 50 per cent. of the total volume of liquid we have one of the so-called spirituous liquors—brandy, whiskey, gin or rum. These liquors owe their individual aromas and flavors to relatively insignificant traces of essential oils and organic esters derived from the particular material which was fermented. Just after they are made they also contain small quantities of distinctly deleterious substances (alcohols other than ethyl alcohol), which taken together are often referred to as fusel oil. These other alcohols should be removed before the liquor is put on the market. The old-fashioned way of removing them was to allow the crude liquor to remain for some years in oaken casks; the wood of the casks gradually absorbed some of the injurious ingredients, while others were oxidized by the action of the air and some coloring matter was extracted from the wood. Such a time-consuming process is not in harmony with modern methods, so we have numerous chemical processes for removing the undesirable constituents. We can impart what color we like with more or less burnt sugar and thus artificially 'age' our spirituous liquors and wines in short order. The number of patents allowed upon processes of this character is surprisingly large. A spirituous liquor is thus cheap stuff at the best, not worth intrinsically a tenth, often not a hundredth, part of its retail price.

The manufacture of whiskey, rum and the like, then, is really a step in the process of the manufacture of ethyl alcohol for commercial use. The alcohol, still too dilute, is subjected to another distillation; it is 'rectified.' This rectification is carried out with the assistance of an ingenious but simple contrivance with the somewhat pompous name of dephlegmator. A dephlegmator consists essentially of a series of chambers, one above the other, each succeeding chamber a

[4] For particulars see any one of the numerous excellent texts on the subject. Among the best are, 'Handbuch der Spiritusfabrikation,' by M. Maercker, eighth edition, and 'Practical Treatise on the Distillation and Rectification of Alcohol,' by W. T. Brannt.

little lower in temperature than the one beneath it. The alcohol vapor and water vapor from the still beneath pass through this dephlegmator, and it is readily seen that much of the water and some of the alcohol must condense in it and trickle back into the still. Inasmuch as alcohol condenses at a lower temperature than water it has the better chance to pass clear through, and into the condenser and receiver. Many modifications of this machine are on the market and they are all efficient. It is an easy matter, with it, to obtain 80 per cent. to 90 per cent. alcohol, and not difficult to obtain 95 per cent. alcohol. The last four or five per cent. of water clings hard to the alcohol and can not be removed by distillation alone. If it is desired to make yet purer alcohol, some substance such as lime, which combines eagerly with water, must be added to hold the water back, and then practically pure alcohol may be distilled off. Pure alcohol containing no water (100 per cent.) is known as absolute alcohol. But such pure alcohol is needed only for a few special chemical processes; there is no general demand for anything better than 95 per cent. Indeed, absolute alcohol has what may be called an avidity for water; it is hygroscopic, and if left in an open bottle will soon collect moisture out of the air and dilute itself.

It is evident that any distillery in the country—and there are about one thousand of them producing upwards of one hundred and fifty millions of 'tax gallons' a year—can increase its output to correspond to the demand which may spring up. The permission to market the product free of tax, if denatured, will then, in the first instance, merely furnish another outlet for the products of these distilleries. A new factory will find itself immediately in competition with the old established plants.

The question next arises, are there any methods of making alcohol other than those by which spirituous liquors are made? In the sense that spirituous liquors are essentially nothing but more or less dilute alcohol such other methods are obviously impossible. But there are methods starting with very different raw materials.

Berthelot, the French chemist, long ago showed how ethyl alcohol might be made synthetically from inorganic materials. The destructive distillation of coal gives us coal gas, and one of the constituents of this is ethylene. This ethylene will dissolve in sulphuric acid forming ethyl-sulphuric acid. If we add water and distil, ethyl alcohol is given off and collects in the receiver, while the sulphuric acid may be recovered in its original condition. At the present time we can start even farther back than Berthelot's starting point. A mixture of lime and charcoal heated in an electric furnace will give us calcium carbide. This calcium carbide, with water, will give us acetylene, and the acetylene will combine with hydrogen to form ethylene. Then the rest of the process follows the outline laid down by Berthelot. This amounts to making our alcohol out of charcoal and water, and electrical energy derived from water power, with the assistance of some chemical reagents, which can be recovered and used over again. The process is simple and practical, but it costs considerably more to make alcohol this way than by fermentation, therefore there is no likelihood that installations on this plan will be put into operation yet awhile.

Now and then articles appear in the newspapers with such titles as 'Alcohol from Sawdust,' or 'Alcohol from Old Newspapers,' titles calculated to rouse the interest (perhaps the cupidity also) of readers, and conveying the impression that here at last is a new and brilliant discovery. There is nothing very new about it. Alcohol was first made from wood about one hundred years ago, and chemists have turned their attention sporadically to improving the methods ever since.

In round numbers 50 per cent. of the weight of wood is cellulose, a substance containing the same elements, in the same proportions by weight, as starch. Starch, under the influence of a suitable enzyme, or of a dilute acid, can be converted to fermentable sugar; and so can cellulose, although with greater difficulty and much less completely. Newspapers are made from wood pulp and are almost wholly cellulose. Many other things are largely cellulose, for instance, corn stalks, linen, hemp, flax, cotton (cotton wool is practically pure cellulose). From any of these ethyl alcohol may be made, indeed, Melsen of Brussels, as long ago as 1855, appears to have amused himself by seeing how long a list of substances he could compile from which he could say he had made ethyl alcohol.[5] His list included, besides those materials already mentioned, such things as dead leaves, stubble, straw, chaff, sweepings from malt, carrot tops, sponges, even birds' nests!

A complete history of all the partial successes would be tedious to any but professional chemists. The difficulty has always been, and still is, that only a small percentage of the cellulose present can be converted into fermentable sugar. This means that large quantities of material must be handled, large amounts of acids must be used, a great deal of fuel must be burned in heating these large quantities, and, after all, a relatively small amount of alcohol is obtained. If a weight of alcohol equal to 7 per cent. of the weight of the wood is secured, the yield must be considered good. Even this sounds promising because wood is cheap. But it should be understood that it is not the cost of the raw material which constitutes the obstacle; it is the cost of treatment.

Simonsen's and Classen's processes may be taken as illustrative of the best present methods for making ethyl alcohol from wood. They are being tried on a commercial scale in Germany.

[5] See Dingler's *Polytechnisches Journal*, Vol. 138, p. 426, 1856.

A large cylindrical vessel, of a capacity somewhat over 1,600 gallons, lined with lead which is not attacked by dilute sulphuric acid, is mounted in such a way that it may be revolved to agitate the contents. It is strongly built to resist considerable pressures. Such an instrument, whether large or small, intended for carrying out reactions under the combined influence of heat and pressure, is called an autoclave.

In Simonsen's process the autoclave is charged with 100 kilograms (220 lbs.) of sawdust and between 300 and 500 kilograms of dilute sulphuric acid (0.5 per cent. acid). Steam is blown in through openings in the axles until the whole has reached a temperature of 100° Centigrade (212° Fahr.), when the autoclave is closed. Then it is heated to about 175° Centigrade, the pressure in the interior simultaneously rising to about 135 lbs. per square inch. These conditions are maintained for about half an hour, while the contents are thoroughly stirred by rotation. The autoclave is then opened and the liquid is filtered off from the solid residue. A portion of the cellulose, under the influence of the acid, the heat and the pressure, has been converted to glucose, fermentable sugars, which are soluble and so are contained in the liquid, the filtrate. The solid residue is made up into briquettes for fuel. The acid in the filtrate is almost neutralized with lime (it is desirable to leave it feebly acid), and this necessitates another filtration, for the neutralization results in the formation of a solid precipitate of calcium sulphate which must be removed. Yeast, and a small amount of nutrient material for the yeast, are then added, and the whole is maintained at a temperature of 25° Centigrade for from three to five days. At the end of this time the fermentation is complete. The first distillation yields a 15 per cent. alcohol and a second distillation brings the concentration of the alcohol up to about 75 per cent.

Pine and fir wood give about the same quantities of alcohol, birch is better for the purpose. In a general way hard woods appear to give better results than soft woods. Seven liters of absolute alcohol from 100 kilograms of sawdust containing 20 per cent. of moisture must be considered a satisfactory yield.

Simonsen estimates that he can make 100 liters of absolute alcohol for 5.86 Marks, that is, at a cost of about 5½ cents a gallon. If this estimate were strictly correct, the process could compete with those based on the direct fermentation of agricultural produce; if it were strictly correct, it is reasonable to suppose that there would be more factories making alcohol from wood than there are.

Classen's process is similar to Simonsen's, but the chemistry of it appears to be more economical. Classen runs sulphur dioxide gas (which can be easily and cheaply obtained in any of the numerous localities where there are deposits of iron pyrites) into the autoclave. The sulphur dioxide gas, under pressure, penetrates the pores of the wood, and uniting with the moisture there forms sulphurous acid, which serves the purpose of the more expensive sulphuric acid in Simonsen's process. When the autoclave is opened the excess of sulphurous acid gas is easily driven off and may be used on a fresh portion of wood. Furthermore, as less acid is left, less lime is required for the neutralization which must precede the fermentation. The claim is made that 25 gallons of absolute alcohol have been made from one long ton of sawdust by Classen's process.

Numerous modifications have been suggested, tried and patented, but this is not the place to enter upon a detailed account of these refinements. Perhaps the most interesting is the claim made by Gentzen and Roth in their patent that the addition of ozone, while the wood is being acted upon by acids and is under pressure, materially increases the amount of cellulose converted into dextrose, glucose and fermentable sugars.

The methods may be said to be on the verge of financial success and some small change or addition may any day convert a moderately profitable process into a brilliant success. Problems for physical chemists abound in these processes. We need to know exactly the most favorable concentration of acid, the best temperatures and pressures to be applied and the proper length of time during which the acid, heat and pressure should be allowed to act. Some work has been done on these questions and more is being done. For instance, it has been proved that prolonged action of the acid is harmful, for fermentable sugars which are formed early are later destroyed. It is therefore necessary to interrupt the process at the right time. Such experiments cost money and the time of highly educated men, and no one would dare to say positively that they would result in the discovery of a bonanza. Unfortunately, our manufacturers do not yet realize of what value truly scientific, highly trained, high-priced men would be to them, while the German manufacturers do, and so we may expect these, and almost all other such experiments, to be carried out, and the results to be obtained, in Germany. We shall get them after they have passed through the patent office and shall, very likely, soon be making large quantities of ethyl alcohol from wood, paying royalties to Germans for the privilege.

The suggestion has been made that a process for the manufacture of alcohol might be run profitably in conjunction with wood-pulp paper mills. There does not appear to be the least chance of utilizing the waste from the end of the sulphite process because it contains little or nothing fermentable. It has already been subjected for a long while to the action of sulphurous acid and the fermentable sugars, produced by a brief action of sulphurous acid on cellulose, have been destroyed again by the prolongation of the action.

But, in the manufacture of the pulp, the wood chips are often given a preliminary treatment to soften and partially disintegrate them. It seems perfectly possible that a liquor might be obtained at this stage of the manufacture which could be worked up into alcohol.

Denaturants

The properties which an ideal denaturant should have may be summed up under five heads and they are as follows:

1. It must render the alcohol undrinkable.

2. It must be cheap, otherwise the advantages of 'free' alcohol are lost.

3. It must be separable from the alcohol only with difficulty and at considerable cost.

It seems to the writer that government officials show a tendency to be more cautious than necessary regarding this feature of denaturing agents. Such a thing as a denaturant which a chemist could not remove probably does not exist, and so it is wholly a question of the degree of difficulty, and the cost, of the purification. If this difficulty and cost be never so little more than those involved in the manufacture of new alcohol from raw materials, it should be considered as fulfilling the requirements. Dishonest individuals, bent on swindling the government out of its revenues, would set up illicit stills rather than attempt to 'renature' denatured alcohol. But the government demands are much in excess of this standard.

4. It must be readily detected, in order that revenue officers may determine with ease whether a given liquid contains denatured alcohol or not.

5. It must not interfere with the use of the alcohol for those purposes permitted by law.

It is by no means easy to find substances fulfilling all these requirements; in fact, although the list of possibilities has been gone over and over again by the ablest living chemists for a matter of twenty years or more, the subject is by no means closed. All the denaturants tried and proposed are unsatisfactory in one way or another, and the governments of Russia, France and Germany offer prizes ranging from $4,000 to $20,000 for any denaturant which can be proved to be a distinct improvement over those in use.

Wood spirit, by which is meant, as has already been said, a crude methyl alcohol containing many impurities, notably in the neighborhood of 25 per cent. of acetone, obtained as one of the products of the dry distillation of wood, is one of the most satisfactory denaturing agents. It is difficult to remove from ethyl alcohol, it is readily detected and it is fairly cheap. Alcohol, denatured by the addition of 10 per cent. of wood spirit and nothing else, has been on the market in England for years under the name of 'methylated spirit.' On the other hand, it does not impart to the alcohol such a repulsive odor and taste but what some perverts drink it if nothing else alcoholic is obtainable. According to the *Lancet* and other English papers, this terribly injurious habit has already reached alarming proportions and is on the increase. A penny will buy in 'methylated spirits' as much alcohol as is contained in a glass of whiskey.

One of the strong arguments brought forward in support of the 'free alcohol' measure was that methyl alcohol had been substituted in numerous industries where ethyl alcohol would have been better, and that the health of those obliged to work constantly in an atmosphere laden with the vapor of methyl alcohol was seriously impaired. The continuous inhalation of the vapor causes the same symptoms, in a milder degree, as those following the drinking of the alcohol, notably affections of the eyes. Those whose business it is to denature alcohol with wood spirits unavoidably labor under these disadvantages, but denatured alcohol containing 10 per cent. of the wood spirit will cause troubles of this character only under exceptional circumstances.

To make denatured alcohol yet less potable, German law requires the addition of a second substance, pyridine. The danger can not be wholly eliminated, as there have always been found at least a few so degenerate as to drink the most disgusting mixtures if only they contain alcohol. The so-called pyridine bases are obtained from the distillation of bones and also from tar. They constitute a somewhat oily liquid, soluble in both alcohol and in water, and they have such an utterly repulsive odor and taste that the addition of small quantities permits of the material reduction in the amount of 'wood spirit' used in denaturing. In Germany, alcohol is denatured by the addition of 2 per cent. of wood spirit and ½ of 1 per cent. of these pyridine bases.

But these pyridine bases have serious disadvantages also. They are volatile, and when denatured alcohol containing them is burnt in a spirit lamp the penetrating and highly unpleasant odor is perceptible in the room. They are combustible and should be wholly consumed, but when the lamp is blown out the parts about the wick remain warm and this heat volatilizes a portion of the liquid. If much of the vapor of pyridine be breathed it produces a severe headache, the same sort of seemingly unendurable pain which is produced by inhaling the vapor of nitro-glycerine. The injurious effect of pyridine on the health of those employed in denaturing alcohol has been the subject of discussions in the German Reichstag. The government of Germany permits the addition of small quantities of lavender oil to partially disguise the detestable odor, and recently has permitted a reduction in the required amount of pyridine bases, substituting for it some benzine.[6] The experience of Germany indicates that pyridine, in spite of its disadvantages, is, on the whole, the best general denaturant known.

In Austria-Hungary the standard denaturant is practically the same as in Germany. In France it is much the same as in England—to 100 liters of alcohol are added 10 liters of wood spirit which must contain 25 per cent. of acetone and certain other impurities. Besides this, other substances must be added, the nature of the second substance varying according to the destination of the product. For instance, if the alcohol is to be used for heating, the addition must be half a liter of 'benzine'; if it is to be used for lighting, four per cent. of resin must be added.

We are to have our choice between the methods of France and of Germany. According to Regulations No. 30 of the United States Internal Revenue and to circulars Nos. 680 and 686 issued by the Treasury Department, alcohol may be denatured by adding to each hundred liters of alcohol of not less than 180° proof, ten liters of wood spirits and half a liter of benzine, or by adding to that quantity of the alcohol two liters of wood spirit and half a liter of pyridine bases. The wood spirit, benzine and pyridine bases, with which the denaturing is to be done, must be 'approved.' "The methyl alcohol submitted must be partially purified wood alcohol obtained by the destructive distillation of wood." "It must contain not more than 25 or less than 15 grams per 100 c.c. of acetone and other substances estimated as acetone." . . . "The benzine submitted for approval must be a hydrocarbon product derived either from petroleum or coal tar." "It must be of such character as to impart a decided odor to ethyl alcohol when mixt [*sic*] with it in the proportion of one half

[6] This word benzine is sadly overworked. Spelled with an *e*, benzene, it is the correct scientific name for a definite chemical compound of the composition represented by the formula C_6H_6. Spelled with an *i*, benzine or benzin, it is often used to mean benzene, toluene, xylene, mesitylene, or several other things obtained from the distillation of coal, or a mixture of any two or more of these things. More frequently it means any one of the score of substances obtained in the distillation of crude American petroleum before the temperature is high enough to drive off what we call kerosene. That is to say, it may mean rhigolene, cymogene, gasolene, or naphtha, petroleum-ether or ligroin, or a mixture of these. As these are themselves mixtures, the confusion is worse confounded. Many, if not most chemists, in an effort to avoid misunderstandings, adopted the German word benzol to indicate that definite and important compound C_6H_6, but the relief was for but a little while. Now benzol, too, has begun to be used in certain industries, as if it were synonymous with benzine or benzene. When one of these three words is used it is impossible to tell immediately what is meant; the meaning may be deducible later from the context, frequently it is not, as the chances are almost even that the speaker himself does not know. It covers a multitude of inaccuracies; perhaps that is why the word is so popular.

of one part by volume." The rest of the tests which must be applied and to which the denaturants must conform are not of general interest.

As the presence of denaturing agents prevents the use of the alcohol in numerous processes, other countries have long lists of substances used to partially denature alcohol destined for use in particular industries, partially protecting it, as it were, in transit from the factory in which it is made to that in which it is consumed. For instance, in France, alcohol intended for use in the manufacture of aniline dyes may be denatured by adding to 50 liters of the alcohol 50 liters of nitro-benzene or of nitro-toluene, and 10 grams of sodium hydroxide dissolved in 20 liters of alcohol. For varnishes, the product put on the market must contain 75 grams of resin per liter. There are in all about fifty different processes allowed for partial denaturing for as many special purposes. In Germany, for the manufacture of polish, alcohol may be denatured with one half of one per cent. of turpentine; for the manufacture of varnish, with 20 per cent. of a solution of one part shellac in two parts of alcohol; for the manufacture of the anesthetic, ethyl ether, and numerous other medicinal substances, with 10 per cent. of ethyl ether; for the manufacture of acetic acid, or vinegar, with 6 per cent. or 8 per cent. of acetic acid; for the manufacture of smokeless powders, 1 per cent. of camphor; and so on through a list as long as that in France.

Partially denatured alcohol never wholly leaves the watchful care of the guardians of the law. No list of partial denaturants permissible in this country has been determined upon. Interested parties are invited to make their suggestions and requests and these will be considered by the commissioner of internal revenue.

Uses of Denatured Alcohol

Every one knows from actual experience how clean and convenient spirit lamps are. There is never any soot nor smelly oil to be cleaned up, lamp chimneys remain clear and transparent and wicks require no trimming. The products of the combustion of ethyl alcohol are water and carbon dioxide, absolutely odorless and as harmless as any products of combustion can possibly be. It is much less inflammable than gasoline, and therefore safer. Water thrown on burning alcohol will immediately extinguish the fire, as alcohol is soluble in water in all proportions, while water thrown on burning oil or gasoline only makes matters worse. Oil and gasoline are lighter than water and are not soluble in it, so they float on top and continue to burn; throwing on water only spreads the fire.

Measured in terms of units of heat, calories, a given weight of ethyl alcohol is about twice as effective as an equal weight of petroleum. Its convenience, cleanliness, safety and adaptability to almost any sort of burner in almost any place, is such that it would undoubtedly be preferred to all other fuels for all purposes if it were not for the cost.

The presence of any denaturing agent robs it, to a greater or a less extent, of some of its natural advantages. The odor of the denaturant is apt to be detected either before, during or after combustion.

Denatured alcohol has been found to dissolve some metals, notably brass. Of course the solvent effect is not rapid, but yet it is constantly under way and necessitates repairs to metallic lamps. The metal dissolves as a salt which is left on the wick when the more volatile alcohol burns, encrusting the wick and necessitating occasional cleaning or trimming. This crust interferes with the efficiency of the lamp whether it be used for heating or for light. But that is not the worst feature of the solution of metals in the alcohol. The small quantities of metal are in part volatilized and are deposited on any object which is being heated. Platinum crucibles are quickly ruined by this action and this alone is sufficient to absolutely prohibit the use of denatured alcohol in chemical laboratories.

Some investigations have been made to determine which constituent of denatured alcohol is responsible for this solvent action. Neither pure ethyl alcohol nor pure methyl alcohol nor pure pyridine, nor yet pure 'benzine' would dissolve metals. The most recent work appears to fix the blame on small quantities of organic esters, formed during fermentation and left in the alcohol itself, which of course is not so carefully purified, if it is to be denatured, as if it were intended for drinking purposes. This might appear to be a small detail, but is not, for it affects the usefulness of denatured alcohol for heat, light and power also. Anything corrosive in action could not be tolerated in the cylinder of an engine any more than it could in contact with a platinum crucible in the chemical laboratory.

The efficiency of a gas engine is the greater the greater the compression of the charge, the mixture of gas or vapor and air, before the explosion. Compression can not be carried far with gasoline, for compression, of course, heats gases, and gasoline catches fire so easily it is apt to explode prematurely, *i. e.*, while the piston head is traveling the wrong way. The fact that alcohol is less readily inflammable makes it possible to compress mixtures of air and alcohol much more without danger of premature ignition. Therefore a larger percentage of the power in alcohol can be utilized, it is more efficient. In parallel experiments Diesel obtained 17.6 per cent. of the power in kerosene as mechanical energy, 20.5 per cent. of the power in gasoline, and 31.7 per cent. of the power in ethyl alcohol. Those competent to judge say it will not be difficult to obtain 40 per cent. of the power in alcohol as mechanical work done. But, on the other hand, there is less power in alcohol than there is in the petroleum products, weight for weight, as is shown by the relative heats of combustion to which reference has already been made. So that, at the present time, it is about an even thing between the two sources of power, weight for weight, with the chances good that American ingenuity will develop an alcohol motor superior to the gasoline motor.

Alcohol engines used abroad require a preliminary warming up before they will start. They are sometimes started with gasoline, and sometimes 25 per cent. of gasoline is added to the alcohol to cause it to ignite more readily. This may militate against alcohol as a motive power at the outset, but even now there are to be found in the current literature descriptions of alcohol engines which will start even without this brief preliminary warming.

Numerical data as to the consumption of alcohol per horse power are abundant. On the average, in small motors, the consumption at present may be taken at about one and a half pints of alcohol per brake horse-power hour. Professor Lucke, of Columbia, commissioned by the government, is now engaged upon a series of exhaustive tests of alcohol motors, and his results will be interesting.

Alcohol burns with a non-luminous flame. There are two general methods by which it may be made to furnish light. First, by adding some liquid, like 'benzine,' to it, which causes the flame to become luminous, and second, to utilize the heat to heat a mantle such as the ordinary Auer von Welsbach gas mantle, to incandescence.

A mixture consisting of 65 per cent. to 85 per cent. denatured alcohol and 35 per cent. to 15 per cent. of the distillate from coal tar, boiling between 150° and 160° Centigrade (mainly mesitylene) is on the market in Germany. It is known as 'Plehn's fluid' and burns with a luminous flame.

Before the discovery of mineral oil a mixture of ethyl alcohol and a very pure turpentine which was known as camphene[7] was largely used as an illuminant. It is of course possible to return to the customs of our grandfathers, but unfortunately the price of turpentine has risen enormously in the meanwhile.

On the whole the other method, burning alcohol with a non-luminous flame to heat a mantle on the plan of the Welsbach gaslight, is probably to be preferred to methods for making the flame itself luminous. It may be a little discouraging to prospective patentees in

[7] Camphene is another word almost as ambiguous as 'benzine.' Camphene is the correct scientific name for a definite chemical compound, a solid terpene of the formula $C_{10}H_{16}$. Turpentine is a mixture of pinene, also of the formula $C_{10}H_{16}$, but a liquid, and other similar substances; purified, it contains a higher per cent. of pinene, but is a mixture still, not pure pinene and certainly not camphene. This appropriation of scientific names by dealers to imply a higher degree of purity than actually exists in their wares is a constant source of confusion and a real hindrance to the dissemination of accurate knowledge.

this country to learn that lamps burning alcohol for light on this principle are to be numbered literally by the hundreds in Germany to-day. At a recent competition in that country for a prize for the best lamp no less than 99 new designs were entered.

These lamps are efficient, the best using only 16 to 20 cubic centimeters of 95 per cent. alcohol for ten hefner candle power hours. They are long lived, and will last without renewal of wick or mantle much longer than the ordinary incandescent electric lamp lasts. Not the least of their advantages in these days of domestic difficulties and problems is their extreme cleanliness.

The questions as to the efficiencies of the denatured alcohol lamps may be summed up by giving the results obtained by Professor Rousseau of Brussels. He has carried out many experiments and concludes that denatured alcohol at 31 cents a gallon furnishes a slightly cheaper light than kerosene at 15 cents a gallon.

But the subject is by no means closed. These alcohol lamps are slow in getting started and a minute or a minute and a half elapses after the match is applied before they are emitting their maximum light. This is because a portion of the alcohol must be vaporized before the heat is great enough to raise the mantle to full incandescence. This little detail is enough to condemn the lamps with many. That their imperfections are fully recognized is demonstrated by the fact that the government of France offers a prize of $10,000 for a device to burn alcohol under exactly the same conditions under which petroleum may be burned for lighting purposes. Similar prizes are also awaiting the fortunate inventor in Germany.

Questions involving the use of denatured alcohol in chemical industries must be omitted here, as anything like an adequate exposition would require much space. They are questions of great magnitude, involving perhaps the establishment of large and important manufactories.

In these as in all the uses of alcohol the presence of any denaturing agent whatever is at best a great nuisance. As was justly said by Professor Erdmann, of Halle, in a discussion of the subject, "It is most illogical and contrary to the most self-evident principles of economy to go to an expense in order to make a useful material less useful." But, as a recent newspaper editorial said, "It is one of the penalties which humanity as a whole must pay for the failings of a minority."

Costs and Prices

The cost of ethyl alcohol to the manufacturer is a subject upon which divergent opinions are held. It depends upon so many variable factors that it is doubtless different for each manufacturer, and moreover must differ from year to year if not from month to month. Calculations as to what it should cost made from a given raw material by a certain process are apt to be misleading. Simonsen's calculation that a gallon of ethyl alcohol may be made from wood by his process for 5½ cents is an illustration of this. Results of experience on a commercial scale are more trustworthy.

Ethyl alcohol made from the molasses from sugar cane in Cuba and South American countries is sold at 10 cents a gallon. It takes about three gallons of this molasses to make one gallon of 100 per cent. alcohol. Assume that this molasses can be delivered at our seaports for 3 cents a gallon, and it is safe to say that alcohol can be made at those localities for 12 cents a gallon.

Evidence was taken by the Committee on Ways and Means before the passage of the present law and brought out many interesting facts. In a letter to the committee, Mr. M. N. Kline, referring to a distillery in Peoria, Illinois, said that alcohol had been made there, from corn, at a cost of 5.2 cents per proof gallon, and that the average cost during the last ten years was 10.78 cents per proof gallon. The low value corresponds to about 10 cents, the average value to about 20 cents per gallon of 95 per cent. alcohol. Before the same committee Mr. Batchelder estimated that with corn at 30 cents a bushel 90 per cent. alcohol could be made for 11 to 12 cents a gallon; with corn at 40 cents a bushel, for about 16 cents a gallon. He thought a fair price to distillers would be 20 cents a gallon. The concensus of opinion appears to be that corn is the most promising source of alcohol in this country, and the comparison, demonstrating the superiority of corn over potatoes, from which the bulk of the alcohol to be denatured is made in Germany, is carefully worked out by Dr. H. W. Wiley, of the Bureau of Agriculture, in recent *Farmers' Bulletins*, Nos. 268 and 269. In these bulletins Dr. Wiley also calls attention to the great possibilities of the cassava root as a raw material.

Secretary of Agriculture Wilson holds out very rosy prospects, and thinks it not impossible that alcohol may be made for three cents a gallon from corn cobs and from the juice of cornstalks at a certain period of their growth. Let us hope that Secretary Wilson's estimates may be justified by the events.

The retail price of 95 per cent. alcohol in Germany, converting the values to our units of volume and money, has been as low as 15 cents and at the present time is about 30 cents a gallon. That these prices do not always return satisfactory profits to the distillers is evident from an article published by Dr. E. Parow in the *Jahrbuch des Vereins der Spiritusfabrikanten in Deutschland* for 1906. After giving figures showing that there has been an overproduction of potatoes in Germany, because the increase in the demand for the products, alcohol and starch, has not kept pace with the increased crops, he continues: "The old distilleries are still capable of existence to-day because they have moderately satisfactory established markets for their products, but more than this because they have in great measure already paid for themselves through sinking funds. New distilleries have not got this support. Money invested in them may be considered from the outset as lost. Hence one should advise as strongly as possible against the construction of new distilleries." Such pessimism as this is extreme, and German conditions are not American conditions. Still, at a time when we hear almost nothing but highly favorable accounts, it is perhaps well to call attention to the fact that there is another side to the question.

In the *Farmers' Bulletins,* already referred to, Dr. Wiley expresses the opinion that alcohol will not be sold in this country for less than 40 cents a gallon. Judging from the evidence given before the committee of congress and some of the other facts recited above, this price ought to furnish several eminently satisfactory profits. It may be hard to find any distiller of spirits ready to say that 20 cents a gallon is a fair price for his product, but it was, perhaps, easier to get close estimates before the passage of the bill than it is now that the bill has passed. It is to be hoped that the distillers will realize the danger that they may kill the goose, even before it has begun to lay golden eggs.

Much depends upon this question of price. So far as one can judge, alcohol at 35 or 40 cents a gallon will be upon even terms with kerosene at present prices for lighting purposes; even at a higher price it will be preferred by many on account of its cleanliness and safety. For the same reasons it may be preferred for running small motors about farms, for threshing machines, etc. At 20 cents a gallon it is about an even thing whether it will be chosen in preference to gasoline for automobiles.

On the other hand, the price of petroleum products may be lowered if the competition of alcohol becomes strong. Mr. Young of Michigan, in his speech opposing the passage of the bill,[8] said petroleum products could be bought in New York for 7 and a fraction cents a gallon by the barrel, and for 4 and a fraction cents a gallon in bulk. He also estimated the production of petroleum products in 1905 at the enormous quantity of 5,000 million gallons, and believes that the Standard Oil Company could sell for even less than 4 cents a gallon, if they thought it necessary, in order to retain their markets, and to drive out alcohol. Such figures make the prospects of denatured alcohol for heating and for power appear dubious.

In the hearings before the committee of Ways and Means it developed that in the northwest, for instance in North Dakota, petroleum

[8] See *Congressional Record*, Vol. 40, part 6, pp. 5317–5334.

products are high, while corn is cheap. Here, at least, denatured alcohol may be expected to displace gasoline. What applies to North Dakota applies equally well to many semi-isolated agricultural districts far from large markets, provided the alcohol can be made on the spot.

Whether or not the denatured alcohol business will become the property of a trust which will regulate prices is an interesting question. If the Standard Oil Company looks with such perfect equanimity at the advent of denatured alcohol upon the market, as Mr. Young attributes to it, it is strange rumors should so constantly appear in the newspapers that the Standard Oil Company is buying up the distilleries. These rumors might, indeed, be ascribed to the agitation in favor of the bill before it was passed, but this does not explain the persistence with which these rumors have been repeated during the last few months, since the passage of the act. The experience of other countries is worth noting in this connection. During the last year or so an alcohol trust has been formed in Spain, with headquarters at Madrid, and another was formed a year ago in Greece, with headquarters at Pyræus. Even one of the oldest of countries appears willing in these days to learn the tricks of trade from one of the youngest.

Any monopolization of the business of making alcohol would be totally impossible if nature were allowed to take its course. The process of manufacture is so simple and so readily carried out, and on a small scale requires so small a capital outlay, that groups of farmers could easily associate themselves and construct distilleries to convert their surplus crops into alcohol. Nearly every county in an agricultural district could have such a distillery and its products would find a ready market at home for light and power. The Commissioner of Internal Revenue, Mr. Yerkes, is reported to have been asked, some months ago, if there was anything in the free alcohol bill to prevent farmers and smaller merchants from so banding together; whether any provision of the bill would result in throwing the new industry into the hands of the distillers or of any other trust. He replied, 'Nothing whatever.'

A study of the rules and regulations which were issued September 29, 1906, to govern the manufacture, denaturing and sale of denatured alcohol, leads one to believe that he has supplied this omission; without a doubt unwillingly, and through a sense of his duty as custodian of the revenues, because Mr. Yerkes is well known to favor the 'free alcohol measure,' but none the less effectually. Such a labyrinthine web of restrictions and obstacles is surpassed in no other country or language, and is equaled only by the present United States Government restrictions on the distilling of spirituous liquors. It is more than likely to deter any from endeavoring to make and sell denatured alcohol, except those who have already devoted a large share of a studious life to an endeavor to understand the present rules governing the distillation of spirituous liquors.

A few of these regulations are enough to give a fair idea of the whole 152 which require sixty-two good-sized, closely-printed pages for their statement. Any one desiring to denature alcohol must construct a bonded warehouse on the distillery premises. The most minute details of its construction are laid down, even to the make of locks used for locking the doors and securing the faucets and openings of the tanks. A room must be provided for an internal revenue officer whose duties appear to be largely to sit in the room and keep the keys in his pocket. "Not less than 300 wine gallons of alcohol can be withdrawn at one time for denaturing purposes." The denaturants after being approved must be kept locked in the bonded warehouse until used. Exact instructions concerning the bookkeeping of the establishment are given. The denaturants must be 'thoroly mixt' [*sic*] with the alcohol in the presence of a revenue officer. If no mistakes have been made thus far (and any mistake involves a stoppage of the process, the filling out of numerous legal blanks, and reference to an endless chain of supervisors, inspectors, collectors, and chemists), the manufacturer may draw off his product 'thru' his approved pipes and locks into receptacles of not less than 5 gallons, nor more than 135 gallons capacity, "all of which receptacles must be painted light green." Under no circumstances is a package containing denatured alcohol to be of any other color. It is to be hoped we may not be left too long in suspense as to the exact shade of green demanded for this momentous purpose. "Upon each head of the package shall be stenciled in red letters of not less than 1½ inches in length by 1 inch in width, the words, 'denatured alcohol.'" Seven other items of interest must be stenciled on the head, but probably through some oversight, the size and color of these letters do not appear to be specified. Complete transcripts of records of the previous month must be sworn to before the tenth of the next month. The form of affidavit is given, nothing seems to be forgotten, even the colors of the inks with which the records are to be written are prescribed.

Next follow regulations for the sale of denatured alcohol, if any one ventures into the precarious business of making it, undaunted by the legal pitfalls and penalties provided. 'Manufacturers of and dealers in beverages of any kind' are not permitted to keep nor store denatured alcohol; they are in danger of the strong arm of the law if they so much as have a light green cask with red letters on it in their possession. Druggists are mercifully exempt from this prohibition. Permits, which must be renewed each year, must be obtained before any dealer can sell denatured alcohol. Apparently these permits cost nothing beyond the trouble of getting them, the filling out of forms, a few oaths, etc. Dealers must make monthly reports under oath of purchase, sale and stock on hand. All premises and all books of denaturers and of all dealers in or users of denatured alcohol must be open at all hours of the day and night to revenue agents and deputy collectors.

There is, of course, an equally elaborate system of safeguards covering the manufacture and use of partially denatured alcohol. If, in the course of a manufacturing process alcohol is used as a solvent and is recovered, it can not be redistilled except in the presence of a revenue agent. An almost overwhelming number of application forms, directions and prohibitions apply to this redistilling of recovered alcohol also.

It does not seem too much to say that the present rules about explode all hopes that small factories can be established in rural districts to convert an overproduction of potatoes, and the like, into fuel, a source of light, or a readily transported and marketable product. It does not seem too much to say that these rules inevitably throw the new industry into the hands of established distilleries, *i. e.*, into the hands of the whiskey trust.

A Standard Oil expert is quoted as reporting that denatured alcohol is not now in a position to rival petroleum products, but that it is a very favorable product to control. It is, indeed, a favorable product to control. Made by the growth of plants utilizing carbon dioxide and water from the atmosphere, it contains nothing but carbon, hydrogen and oxygen. All the rest of the plant may be returned to the soil, which thus is not impoverished. It is the best method known to us to-day to store the sun's energy. By its means the rotation of the seasons can be made to give an inexhaustible supply of light, power and heat. Some way should be found to safeguard our precious revenue, and at the same time to leave this valuable agent for the progress of civilization as free as the air, sunshine and rain from which it is made.

SPELLING REFORM AND THE CONSERVATION OF ENERGY

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THE basis of modern physical science is the conservation of energy. This doctrine, that the sum of the energy in our universe is constant while its modes of manifestation and transformation are indefinitely variable, has been established only within the last century, though vaguely foreshadowed many hundreds of years ago. Assuming the use of any machine for the transmission of energy, the amount of useful work done is less than the amount expended by the source because a part must be absorbed in the production and maintenance of motion in the machine itself, and in friction. With the development of heat and the radiation of this from the machine, energy that was initially available becomes transformed and ceases to be available. Such economic loss is physically a conservation.

The human brain is a machine for the transmission of energy, even though the work thus done may not be so readily measurable as that accomplished through the medium of a steam engine. The assimilation of food is the process by which energy from external sources is applied to the human machine and utilized through the medium of the brain. No physiologist has yet been able to analyze the mechanism of thought, but with the failure of the supply of carbon, hydrogen, oxygen and nitrogen, which in suitable combination constitutes food, the power of thought vanishes with the paralysis of the brain. The function of the educator is to guide and help young human beings to use to the best advantage every part of the human machine, and especially that part whose function is to originate ideas, to convey them by the use of suitable symbols, and to apply them for the benefit of the race.

The use of words for the oral conveyance of ideas, or of what are intended to be such, has always been the favorite occupation of more than a single sex. Every speaker acquires his own habits of expression that become recognized among his associates. A certain amount of what we familiarly call mental energy is put by him into the expression of an idea. Another output of such energy is expended by the hearer in the effort to take in that idea. Success is usually only partial, as every practical teacher will sorrowfully admit. Clearness of thought must precede clearness of expression, and this in turn must precede clearness of apprehension. The man's style may not be ornate, it may not be conventionally elegant, but it is good in proportion to his success in conveying his ideas fully and accurately. In the process of transfer he has reduced the friction and the waste of inertia to the utmost. The least amount of work has been lost in the operation of two machines, the giving and the receiving, which form temporarily a connected system; and the active recipient's attention has been applied with good economy.

Men do not require to be highly civilized before the need is felt for the registration of ideas in addition to their oral transfer. Ideas are first symbolized, and the translation of such symbols into words soon suggests that words may be independently symbolized. The process continues until words are analyzed into their components, and these also are symbolized as letters. The art of spelling is thus born. But whatever the stage of symbolization, the written idea can never be more than an imperfect reproduction of the spoken idea, because symbols are arbitrary. The interpretation of a group of symbols is a synthetic process, and the opportunities for misunderstanding are fairly well proportioned to the complexity of the word machine employed.

The art of spelling is thus a development from early crude attempts to register spoken ideas and spoken words. The same word is often pronounced so differently by different speakers as to be scarcely recognizable. The English language when spoken by a highland Scotch or Welsh tongue to the ear of an American mountaineer fulfills quite well the dictum, commonly ascribed to Talleyrand, that the object of language is to conceal thought. From the very nature of the case spelling must vary as language varies. Orthodoxy may perhaps be as unchangeable as its representatives are prone to claim, but spelling has never been uniform, is not now uniform, and ought not to be more uniform than is the spoken language among the best educated scholars in great centers of population.

So long as literature was limited to manuscripts copied by professional scribes and seen only by the few who could read, and whose tastes prompted them to indulgence in such pleasure, spelling was as unsettled as forms of speech. The invention of printing not only produced a vast increase in the diffusion of reading matter, but tended to unify and give definiteness to the forms of symbolization. The railroad, the steamship, the telegraph and the printing press have been operated conjointly to bring all nations into closer communication than was ever foreshadowed by the optimistic dreams of our forefathers; but the adoption of a single language for the civilized world is still so far away in the future that no one gives the matter any serious consideration. Such unification is conceivable, but if ever approached it must be by gradual and almost imperceptible evolution, and not by prescription from any source, however scholarly and apparently authoritative. A new language, like Volapük, even though theoretically perfect, has not the ghost of a chance of adoption, because nobody is willing to assume the labor of learning it or to use what would not be a practical means of communication.

And so it is with spelling reform. Men have been free to spell in any way that seemed best adapted to the reproduction of what they wanted to convey. Variety in speech has been as natural as variety in personal character, in dress or in amusement. Inconsistencies in fashion will continue as long as men retain their personal liberty to select idioms, words and spellings that suit the individual fancy of the user. So long as a babel of different languages continues on earth will there be a corresponding babel of spellings. There is no remedy but self-interest. In making ourselves understood we are compelled to recognize the conservation of energy. The man who writes a sentence must consider not only his own thought-machine but also that of his reader. Personal liberty to spell as a writer may find easiest or think best is soon limited by the necessity to make himself easily intelligible. If his spelling is very different from what has gradually become the fashion, the blunderer is soon made aware that he is hard to understand, and self-interest teaches him to avoid interposing obstacles between himself and his constituency.

The printing-press has been the great unifier in the establishment of fashion in spelling. But such fashion is not in the least sacred. In the spelling of the English language the fashion has been set for the most part in the printing office by foremen, or by mere type-setters who were entirely innocent of any hostile designs against orthography, etymology or logic. Professor Lounsbury has shown that the type-setting of the earlier books in our language was done mostly by printers who had come to England from the continent. In the city of Strasburg may be seen to-day a statue erected to the memory of Gutenberg, whose first crude invention of type was long unknown in England. Type-setting was initially and most naturally a German art, and it would have been very remarkable if the conservative and self-satisfied Englishman had been found ready to adopt promptly any art that had its origin outside of England. The intruding German or Dutchman could not be expected to possess much English scholarship, and in the printing room nobody could direct him because no directions for spelling existed even among the authors themselves. The Anglo-Saxon language had grown naturally and healthily. The English language was not then known to have any separate existence or special individuality. It later received a large infusion of Norman-French, and the thought of consistency, of uniformity in spelling or in anything else, had not occurred to anybody. Chaucer was limited by no orthographic conventions, and if his spelling could be improved by the Dutch printer his readers probably recognized the possibility that there might be room for improvement. It was not his fault if the improvement was confided to incompetent hands. His spelling was more consistent than that of to-day.

Such being the early development of our 'system' of English spelling, it requires a peculiarly religious spirit to discover in it anything sacred or worthy of special protection. The only protection that can be reasonably asked is the protection of the individual from the trouble of changing his habits, and this collectively means the protection of society from the confusion and general inconvenience that would result from sudden change of any kind if this could be effected by radical reformers. No language exists in which the spelling is even approximately phonetic. Italian, Spanish and German are among the most nearly exemplary tongues; but any one who studies German in America and then goes to Germany to spend a year or two, gradually discovers a good many words of which he has to change his pronunciation. The contrast, however, between German and English is conspicuous. It would be a waste of time to dilate upon the inconsistencies, the foolish freaks and stupid absurdities of English spelling and pronunciation. The facts are quite generally admitted by all who possess even an elementary knowledge of linguistics. The practical question is merely that propounded thirty-five years ago by a famous criminal, 'What are you going to do about it?'

Let it be granted that printers of various grades of ignorance during the last three or four centuries have accustomed the English-speaking public to the most inconsistent spelling with which any civilized people is loaded. All of us have spent months and years of early life in the effort to learn this spelling, not because there is anything educative about it, but because of the unwritten law that inability to spell 'correctly' is a sign of illiteracy. During the childhood of the present writer this idea was emphasized to such an extent that in the spelling class common words were of little interest. He was trained to feel a certain pride in his ability to spell promptly and unerringly such test words as gauge, hough, sough, fuchsia, bdellium, phthisical, eleemosynary, metempsychosis, and tragododidascalicological. The spelling match each week was a source of excitement, perhaps comparable in a small way with such modern dissipation as bridge or football. All of us have gone through this mill with varying grades of success so that our eyes have become accustomed to the absurdities, and our associations are violated when we look upon improved forms. It is easier to recognize 'though' than 'tho'; 'through' than 'thru'; 'kissed' than 'kist'; 'rhyme' than 'rime'; 'thoroughly' than 'thoroly.' Most persons think the improved forms unsightly. This means nothing except that they are unfamiliar.

To reform our language to such an extent as to make it logical and consistent is scarcely conceivable. Attempts to do so have been made on paper, but practically they have resulted in nothing better than rainbow chasing. Our alphabet is radically bad, having a superfluity of symbols for certain simple sounds, and no single symbols for other elements of speech. Most of our vowels are sounded a variety of different ways, the most common ways being inconsistent with the sounds agreed upon in other modern languages. Spelling reformers have been agitating this matter for fifty years, but we are apparently no more ready to reform our alphabet now than when they began. Some of them, accepting the existence of an unchangeable alphabet, have persistently advocated the adoption of a strictly phonetic system of spelling; but, if they have made any practical progress outside of the volumes of proceedings of educational and philological conventions, it has been limited to the few enthusiasts who were willing to acquire the reputation of being peculiar and ill-balanced.

The movements in behalf of alphabetic reform and phonetic spelling have been made in complete disregard of the conservation of energy. The habits of the people must be recognized. A page of English printed in an amended alphabet is, to even intelligent persons, simply unreadable. It has to be slowly and painfully deciphered, like a page of Greek. It may, like Greek, be read if one will be patient enough, but the difficulties are crowded initially, and the man who is not a professional philologist exercises his right of choice and rejects what he finds bristling with difficulties. Let the page of English be printed now in ordinary type, but phonetically. The word 'physics,' for example, is spelled 'fizix.' This also, like Greek, may be deciphered, but the page will require a great waste of energy with no reward beyond the mastery of unnecessary difficulties. Let any business man conduct his correspondence for a single week in such style. His customers are immediately convinced that the object of language thus expressed is to conceal thought, and the pecuniary results may be readily inferred. Let a publisher put forth a new book in phonetic spelling. On neither side of the Atlantic would one reader in a hundred be found ready to buy it, or patient enough to read it if curiosity has prompted the purchase.

The recognition of these great obstacles to reform does not imply that whatever is, is right, or that reform is impossible. Let us assume that a cannon ball weighing half a ton is to be moved by a little child, using nothing stronger than cotton thread. It may be suspended by a steel chain from a support of known height, for example thirteen or fourteen feet, thus forming a big pendulum whose period is readily calculated to be about four seconds. Let the thread be attached to a hook on the side of the ball. A jerk from even a baby's hand is sufficient to snap it. But if a succession of gentle pulls be given at intervals of just four seconds, each too faint to break the thread, a few hours of such light work, patiently maintained, will be sufficient to make the pendulum swing through a perceptible arc. The advocates of alphabetic and phonetic reform have been jerking the thread, and they will continually fail to move the ball so long as they refuse to recognize its formidable inertia. People who are accustomed to bad habits, whether relating to spelling or to anything else, need to be pulled gently, periodically and patiently. They are proof against argument, dictation, ridicule, legislation or physical force; but they will slowly yield if pulled in the right way and in the right succession.

However important may have been the influence of half-educated printers in the fastening of a hereditary spelling disease upon the users of the English language, the responsibility does not rest wholly upon them. Like other people, printers endeavor to adapt themselves to popular demands. The great classical schools of England have done much to infuse Latin and Greek into the language and to cultivate classical forms of spelling. Against the orthographic riot due to the early printers a reaction was inevitable. They gradually discarded many of the worst word forms that had been brought into use, but in the selection of surviving forms they had but small guidance from competent scholars. An approach toward uniformity was made, but it was under the domination of conservatism rather than reason or consistency, and popular habits were formed with no regard for simplicity or etymology. In the earlier English dictionaries by Bailey and Johnson very little was done to correct the prevailing inconsistencies. Johnson's great force of character made him a power among men. His knowledge of Latin was exceptional, but of etymology he knew little and cared less. As a lexicographer he was narrow, prejudiced and illogical. His dictionary was made the basis of Walker's dictionary, which in time attained wide currency on both sides of the Atlantic.

In all of these dictionaries it was apparently assumed that the function of the lexicographer is to record and define the words in current use, but not to search out or expose inconsistencies. The incongruities of our language make the dictionary more important as a reference book than it deserves to be. To this day multitudes of people accept without question what they find as allowed spelling in Webster or Worcester; and they resent any criticism upon what they consider to be established by the favorite standard.

What then are we to do about it?

The first and most important thing is to recognize the facts of human nature and the conservation of energy. This has been done by a small band of scholarly men, who have become incorporated during the year just ended as the Simplified Spelling Board, and to whom has been given the practical support of Andrew Carnegie and Theodore Roosevelt. This board recognizes the futility of trying to coerce the public, of trying to change the alphabet, of trying to secure immediate phonetic spelling, of advocating any radical changes, however desirable these may be theoretically. It has no intention of trying to set the pendulum into motion by breaking the thread. Its chief object is to attract the attention of the public to the history and present condition of English spelling; to convince the public that fashion in spelling is not sacred; that our language is and ought to be a developing language; that development should be guided as far as possible toward simplicity and directness. It advocates the gradual approach to simplicity by neglecting useless letters in words commonly employed. It does not claim for itself authority to standardize our language, but seeks to get rid of the excrescences which make our language unreasonably difficult. It wishes to secure the establishment and extension of good usage, to make it national and international. It does not expect to escape the criticism of those who have learned to love the faults of our tongue, but only asks to be treated with fairness and not to be condemned for what it has never advocated.

As a first step the board has issued a now famous list of three hundred words which are commonly spelled in two or more ways, and it recommends the simplest of these spellings in every case. Many of the simple forms have already gained such currency in America as to be called Americanisms by our British cousins. Fifty years ago very few of them were current here, but their adoption has been steady, especially among business men, and their increasing popularity is based upon the American fondness for directness. On examining this list the present writer has found himself already habituated to the use of more than half of the simplified forms, though the more complex forms were all taught him in childhood. He is not conscious of having ever attained a local reputation for oddity in spelling. The changes in practise have been made gradually and to a large extent unconsciously. The remaining half of the list may perhaps become assimilated in due time, but no sudden change can be made now. It would be too inconvenient and difficult. As an advocate of simplified spelling he is unwilling to subject himself to an implied obligation to reverse old habits at once; but his mental attitude is that of approval and sympathy with a reform that is based on strong common sense. Inertia must be allowed for, and the pull on the pendulum must be properly timed.

President Roosevelt, Mr. Carnegie and the Simplified Spelling Board have been the objects of widely varying criticism. The greatest good they have done has been to focus public attention upon abuses which are of small concern to great people, but of great concern to small people. The little folks at school have no prejudices about orthographic propriety, and no burdens should be piled upon them merely for the sake of maintaining old blunders. An English critic of American ways considers it blasphemy to spell 'Savior' without a *u*. Let the English do as they find best; ours is the American language. Our declaration of independence will involve no bloodshed.

The opposition of Congress, and the consequent necessity for the withdrawal of President Roosevelt's executive order in behalf of simplified spelling, given to the public printer at Washington, was not a surprising development. The sudden adoption of two or three hundred changes at one time was too strong a jerk on the big congressional pendulum. But all these simplified forms will quite surely be incorporated in the great American dictionaries at an early day in their lists of alternative spellings. The public printer will thus be free to secure their gradual use in documents issued by the government. Readers of periodicals in which the simplified forms have already been in use, such as *The Literary Digest*, find no difficulty in taking in ideas, even if such forms as 'tho,' 'thru' and 'prest' are occasionally encountered. These periodicals are quietly doing effective work by dispelling the novelty of the improvements. In deference to public prejudice such forms as 'thru' are perhaps best neglected for the present, while 'tho' is used, since consistency is of little importance in comparison with tact. The Simplified Spelling Board can only recommend; the public will do the adopting in response to gentle and well-timed persuasion, and reasonable respect will be manifested toward the conservation of energy.

In conclusion the following propositions are presented by way of summary:

1. Inability to spell conventionally is not necessarily or deservedly an index of illiteracy.

2. Conventional spelling is a mere fashion, worthy of no respect when it implies the sacrifice of economy. In judging economy we must consider ease in the transfer of ideas. That spelling is best which is most readily intelligible.

3. Nobody can be reasonably expected to adopt more than a few changes at a time. A writer occupies himself with ideas rather than verbal forms. The simplified forms must be applied chiefly in the printing office, where forms are all-important. Change of habit must result chiefly from the unconscious training received by the eye in reading such simplified forms already in print.

4. Children should be taught simplified spelling. They will additionally learn the old conventional forms outside of the school-room, and should be free to exercise their own preferences so long as they are consistent in the employment of either system.

5. The simplification of our spelling does not imply the adoption of a new alphabet, or indulgence in objectionable phonetic eccentricities. All improvements are initially unfamiliar, and those who advocate them may be temporarily considered unfashionable, but reason in fashion has a better chance to prevail in America than in England, or in any other country where our common but necessarily variant language is spoken and written.

6. For the improvement of spelling there is always the need of moderate and practical reformers. The same slow process of change

that has been distinctly perceptible during the last half century may be expected to continue, but at a diminishing rate if nothing is done to accelerate it. All fashions tend toward fixity; and unless change is urged by those who are willing to appear at times a little odd, the old absurdities will for the most part continue indefinitely. The language is not going to change itself as a result of being proved inconsistent. No fashion is ever changed except by the exercise of personal initiative, but to secure change regard must be had for the difficulties experienced by the reader. The writer who adopts the simplified spelling has to be continually thinking of his spelling until new habits are formed, and his reader has to experience a succession of shocks that are at first irritating. The amount of friction in the complex thought machine is decidedly increased until it becomes worn smooth by such friction. Each advocate of improvement must use his own judgment as to the extent of his violation of conventional forms, but such violation must be perpetrated by him just so far as may be consistent with sane recognition of the conservation of energy.

FRITZ SCHAUDINN[1]

By Professor THOS. H. MONTGOMERY, Jr., Ph.D.
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FROM the medical and biological world a genius has been taken, and it is not saying too much to conclude that the only man of the past half century who may be considered in any way the equal of Louis Pasteur is Fritz Schaudinn. Yet when Schaudinn died, on the twenty-second of last June, he was in only his thirty-fifth year. Truly those whom the gods love die young! The work of his life is so recent that only the perspective of time can throw it out in its true proportions; but rarely has it fallen to the lot of any man to receive the quick recognition of value that has been so generally conceded to Schaudinn.

With the exception of a few contributions on the worm *Ankylostomum*, on bear animalcules (*Tardigrades*), and on bacteria, the attention of Schaudinn was devoted entirely to the Protozoa; Dujardin, Max Schultze and Schaudinn, each of these marked a great advance in our knowledge of the unicellular animals, and of them Schaudinn covered the most difficult field. For his study of the Protozoa was an intensive examination of their complex life cycles, undertaken first to elucidate their genetic relationships and the meaning of alternation of generations, and second to break a road to the checking of human diseases. His discoveries are of fundamental importance for the understanding of the genesis of the cell, particularly of the phenomena of conjugation and the reduction of the chromosomes, for our ideas of the genetic relations of the various Protozoan groups, and for the prevention of disease. It may be said that before Schaudinn entered the field almost all human infectious diseases were supposed to be due to bacteria, with the exception of the malaria parasite and certain few agents doubtfully associated with unimportant disorders. To Schaudinn more than to any other belongs the credit of the demonstration that the Protozoa are fully as efficient as the bacteria in transmitting and engendering disease. Indeed, the greatest advance in medicine of the past twenty years may be said to be just this conclusion. Schaudinn's particular merit lies in his insistence that the first step in combating any disease must be to understand the whole life cycle of the disease germ; and his genius, in his admirable and unequaled success

[1] Contributions from the Zoological Laboratory of the University of Texas, No. 83.

in solving each complex life cycle that he undertook to investigate. All his discoveries were comprehensive and thorough, they settled the particular questions examined, and this though he selected problems the most difficult of solution. By all his training he was a zoologist, and he is a splendid instance of the fact that comprehensive results in medicine are possible only to him who has a broad biological foundation on which to build. The study of human disease is to be successful not so much by close study of human parasites only, but rather by investigation, through broad comparisons, of the animal and plant groups to which the parasites belong; in that method only is surety given.

For two years it was my privilege to work in the same room with Schaudinn as a fellow student, in the Zoologisches Institut at Berlin; accordingly, this little account of his life is as much the message of a friend as of an admirer. Of the group of students at that laboratory from 1891 on, Schaudinn was the leader from his great and rare natural modesty, as well as from his forceful character and power of tremendous application. With regard to the latter quality I well recall how on one occasion, while with exquisite ardor he was following the stages of a life cycle, he spent more than thirty uninterrupted hours at his microscope. With all his humor, his hearty laugh and his popularity, he rarely spent an evening at the Weinstube or the Bierhalle, but for his recreation took long walks into the countryside, showing a delight in every phase of nature. Perhaps the chief secret of his success was his almost intuitive ability to select the important phenomenon from the less important, and to focus his mind on that; he never allowed himself to become bewildered by the multitude of the facts, truly a rare gift.

Immediately after his death there appeared an appreciative account of his life by his old teacher, Professor Karl Heider, of Innsbrück; then a second by Professor Gary N. Calkins, of Columbia University, this printed in *Science;* and within the past two months more detailed biographical accounts by Professor Richard Hertwig, of Munich, and F. W. Winter, of Frankfurt-am-Main. The last named is the most complete yet given, and was published in the *Zoologischer Anzeiger*, November 13; it gives a careful analysis of his various papers and labors, together with a complete bibliography.

Fritz Richard Schaudinn was born in Röseningken in East Prussia in 1871. In the laboratory of F. E. Schulze in Berlin he commenced his investigations on Protozoa in 1892. His first years there were devoted to the investigation of free-living species, both freshwater and marine, and the rhizopods in particular. Before he made his doctorate he settled a long controversy by demonstrating that the two forms of many-chambered foraminifera, those with a large and those with a small embryonal chamber, represent different stages in the same life history. He elucidated the life cycle of *Calcituba,* and discovered in it a simple and probably very primitive mode of cell division. The division of the *Amœba* with two nuclei (*Amœba binucleata*) was described, and from Schaudinn dates the concept that the original cell possessed two nuclei. Then he described the copulation of the Heliozoan *Actinophrys,* which was the first account of reduction of the chromatin and caryogamy of any protozoan, compared the processes here with the similar ones in the many-celled animals, and showed that the central granule acted as a centrosome. Conjugation of the spores was also discovered in *Hyalopus,* a foraminiferan; and his discovery of the paranucleus of *Paramœba* has come to greatly modify the older ideas on the genesis of the cell nucleus. These discoveries rapidly succeeded each other, marked a great advance over all preceding studies on the reproduction phenomena of the protozoa, and stimulated others to the same field of study.

Next he turned himself to the analysis of the life cycles of parasitic protozoa, a study of particular difficulty because all such parasites live in successive different hosts. Most men have failed in these studies because they lacked the fertility and resource of Schaudinn in devising experiments. Monumental was his study on the complete life cycle of a coccidian (a sporozoan), a parasite of a centipede (*Lithobius*), made in conjunction with Siedlecki. This gave for the first time the complete history of any sporozoan, and was soon followed by an equally conclusive and thorough research, extending through five years, of the life cycle of *Trichosphærium.* These are classics in the study of the protozoa, and they showed the method by which results are to be reached in the search of the parasites of human disorders. In each of these life cycles there follow upon each other a long line of generations, with great dissimilarity of the successive generations; Schaudinn drove home the conclusion that the unit of study should be the whole life cycle, and his results rendered it probable that many forms of protozoa that had hitherto been regarded as different species might be merely stages of one and the same life cycle. This was one of his major contributions that guided him in his later work and has caused an entire change in progressive medicine.

Schaudinn then left Berlin to become director of the laboratory at Rovigno, on the Adriatic Sea, whither he was called primarily to contribute to the study of the malaria organisms. There he first worked out the life history of *Cyclospora,* the agent of enteritis of the mole, carrying out his method to approach human disorders from a preliminary broad comparative basis. Then he made a valuable contribution to the history of *Plasmodium vivax,* the cause of tertian fever in man; and was the first to see the sporozoites entering living human blood corpuscles. The sanitary recommendations then recommended by him against malaria were adopted by the Austrian government. Further, he made observations on the biology of the mosquito that carries these protozoa. Then he worked out a blood parasite of the lizard, and discovered a Rhizopod, *Leydenia,* in the ascites fluid of man.

His next step was to study the parasites of the human colon, which had been called *Amœba coli.* Schaudinn discovered that this really is two distinct species, one of which is harmless, while the other, *Entamœba histolytica,* he proved to be the cause of human bloody dysentery.

His following contributions were devoted to the study of blood parasites, so-called hæmosphoridia. His initial memoir upon this subject was one of his most important. He studied the three blood-parasites of the owl, known as *Proteosoma, Halteridium* and *Hæmamœba,* which he proved to be stages of one and the same life cycle and to be flagellates and not sporozoa. Here also may be mentioned his conclusion that the organisms of human malaria are also flagellates. In connection with this study he worked out the biology of the mosquito (*Culex pipiens*) that infects the owl, and its mode of transference of the parasites. In his investigation of *Spirochæte ziemanni* he made the important discovery that the two main forms of blood flagellates, *Spirochæte* and *Trypanosoma,* are not bacteria, but flagellates, a discovery that has wonderfully clarified our knowledge of blood diseases.

In 1904 Schaudinn left Rovigno to enter the National Sanitary Commission at Berlin. He was fully recognized as the foremost investigator of Protozoan diseases, and though he had never studied medicine he became its consultant authority in Germany. Unwisely the German government for a time placed hindrances to his free initiative, and forced him to undertake certain work outside of his proper field; he had no choice but to accept these conditions, for he was a poor man with a family to support. Principles of patriotism decided him to decline a call to the professorship of protozoology recently started by the British government for the investigation of tropical diseases. At this time Schaudinn corroborated the interesting discovery of Looss, that the round worm *Ankylostomum* infects the mammalian host not through the mouth, but by entering the skin then being transported by the blood current to the lung, and thence to the intestine.

Perhaps what is the most important medical discovery made by him was that of 1905, when he found in the secretions of syphilitic growths a parasitic flagellate that he named *Spirochæte pallida.* Long had physicians searched for the cause of this disease, one of the most widespread and terrible of human disorders, and it was the crowning act of Schaudinn's life to have found it.

Early in 1906 Schaudinn was appointed zoologist to the Institute for Ship and Tropical Diseases at Hamburg, a position that he gladly accepted, because it gave him perfect freedom for his studies and for the first time in his career an income that freed him from financial cares. But within a few months he fell a victim to intestinal abscesses, from which he had suffered for years and which he may have contracted through infection during his studies on the protozoa of the human intestine.

Most of Schaudinn's memoirs were briefly and concisely written, for he disliked to take time from his observations to put it on writing. As Richard Hertwig says of him, 'he was not a man of the writing table.' With his death, accordingly, as in the case of other great men, many of his important results have been lost to science. His descriptions are remarkable for their lucidity, as his experiments for their simplicity.

He was essentially a phylogenist, an investigator of racial history by the analysis of individual life cycles, and his achievements furnish the best possible evidence of the fruitfulness of phylogenetic study. He never called in to his aid hypothetical units, but each and every step in his conclusions was based directly upon empirical evidence; he was not a theorist, but a demonstrator. Cytology has to thank him for tracing the genesis of the centrosome, of chromosome reduction and conjugation; biology in general for demonstrating the necessity of considering the life cycle as a unit, and for having so greatly extended our knowledge of life cycles; medicine recognizes his lasting influence in the study of malaria, as the discoverer of the disease germs of dysentery and syphilis, and for pointing out the methods to follow in the study of protozoan disorders.

THE VALUE OF SCIENCE

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CHAPTER VI. *Astronomy.*

GOVERNMENTS and parliaments must find that astronomy is one of the sciences which cost most dear: the least instrument costs hundreds of thousands of dollars, the least observatory costs millions; each eclipse carries with it supplementary appropriations. And all that for stars which are so far away, which are complete strangers to our electoral contests, and in all probability will never take any part in them. It must be that our politicians have retained a remnant of idealism, a vague instinct for what is grand; truly, I think they have been calumniated; they should be encouraged and shown that this instinct does not deceive them, that they are not dupes of that idealism.

We might indeed speak to them of navigation, of which no one can underestimate the importance, and which has need of astronomy. But this would be to take the question by its smaller side.

Astronomy is useful because it raises us above ourselves; it is useful because it is grand; that is what we should say. It shows us how small is man's body, how great his mind, since his intelligence can embrace the whole of this dazzling immensity, where his body is only an obscure point, and enjoy its silent harmony. Thus we attain the consciousness of our power, and this is something which can not cost too dear, since this consciousness makes us mightier.

But what I should wish before all to show is, to what point astronomy has facilitated the work of the other sciences, more directly useful, since it has given us a soul capable of comprehending nature.

Think how diminished humanity would be if, under heavens constantly overclouded, as Jupiter's must be, it had forever remained ignorant of the stars. Do you think that in such a world we should be what we are? I know well that under this somber vault we should have been deprived of the light of the sun, necessary to organisms like those which inhabit the earth. But if you please, we shall assume that these clouds are phosphorescent and emit a soft and constant light. Since we are making hypotheses, another will cost no more. Well! I repeat my question: Do you think that in such a world we should be what we are?

The stars send us not only that visible and gross light which strikes our bodily eyes, but from them also comes to us a light far more subtle, which illuminates our minds and whose effects I shall try to show you. You know what man was on the earth some thousands of years ago, and what he is to-day. Isolated amidst a nature where everything was a mystery to him, terrified at each unexpected manifestation of incomprehensible forces, he was incapable of seeing in the conduct of the universe anything but caprice; he attributed all phenomena to the action of a multitude of little genii, fantastic and exacting, and to act on the world he sought to conciliate them by means analogous to those employed to gain the good graces of a minister or a deputy. Even his failures did not enlighten him, any more than to-day a beggar refused is discouraged to the point of ceasing to beg.

To-day we no longer beg of nature; we command her, because we have discovered certain of her secrets and shall discover others each day. We command her in the name of laws she can not challenge because they are hers; these laws we do not madly ask her to change, we are the first to submit to them. Nature can only be governed by obeying her.

What a change must our souls have undergone to pass from the one state to the other! Does any one believe that, without the lessons of the stars, under the heavens perpetually overclouded that I have just supposed, they would have changed so quickly? Would the metamorphosis have been possible, or at least would it not have been much slower?

And first of all, astronomy it is which taught that there are laws. The Chaldeans, who were the first to observe the heavens with some attention, saw that this multitude of luminous points is not a confused crowd wandering at random, but rather a disciplined army. Doubtless the rules of this discipline escaped them, but the harmonious spectacle of the starry night sufficed to give them the impression of regularity, and that was in itself already a great thing. Besides, these rules were discerned by Hipparchus, Ptolemy, Copernicus, Kepler, one after another, and finally, it is needless to recall that Newton it was who enunciated the oldest, the most precise, the most simple, the most general of all natural laws.

And then, taught by this example, we have seen our little terrestrial world better and, under the apparent disorder, there also we have found again the harmony that the study of the heavens had revealed to us. It also is regular, it also obeys immutable laws, but they are more complicated, in apparent conflict one with another, and an eye untrained by other sights would have seen there only chaos and the reign of chance or caprice. If we had not known the stars, some bold spirits might perhaps have sought to foresee physical phenomena; but their failures would have been frequent, and they would have excited only the derision of the vulgar; do we not see, that even in our day the meteorologists sometimes deceive themselves, and that certain persons are inclined to laugh at them.

How often would the physicist, disheartened by so many checks, have fallen into discouragement, if they had not had, to sustain their confidence, the brilliant example of the success of the astronomers! This success showed them that nature obeys laws; it only remained to know what laws; for that they only needed patience, and they had the right to demand that the sceptics should give them credit.

This is not all: astronomy has not only taught us that there are laws, but that from these laws there is no escape, that with them there is no possible compromise. How much time should we have needed to comprehend that fact, if we had known only the terrestrial world, where each elemental force would always seem to us in conflict with other forces? Astronomy has taught us that the laws are infinitely precise, and that if those we enunciate are approximative, it is because we do not know them well. Aristotle, the most scientific mind of antiquity, still accorded a part to accident, to chance, and seemed to think that the laws of nature, at least here below, determine only the large features of phenomena. How much has the ever-increasing precision of astronomical predictions contributed to correct such an error, which would have rendered nature unintelligible!

But are these laws not local, varying in different places, like those which men make; does not that which is truth in one corner of the universe, on our globe for instance, or in our little solar system, become error a little farther away? And then could it not be asked whether laws depending on space do not also depend upon time, whether they are not simple habitudes, transitory, therefore, and ephemeral? Again it is astronomy that answers this question. Consider the double stars; all describe conics; thus, as far as the telescope carries, it does not reach the limits of the domain which obeys Newton's law.

Even the simplicity of this law is a lesson for us; how many complicated phenomena are contained in the two lines of its enunciation; persons who do not understand celestial mechanics may form some idea of it at least from the size of the treatises devoted to this science; and then it may be hoped that the complication of physical phenomena likewise hides from us some simple cause still unknown.

It is therefore astronomy which has shown us what are the general characteristics of natural laws; but among these characteristics there is one, the most subtile and the most important of all, which I shall ask leave to stress.

How was the order of the universe understood by the ancients; for instance, by Pythagoras, Plato or Aristotle? It was either an immutable type fixed once for all, or an ideal to which the world sought to approach. Kepler himself still thought thus when, for instance, he sought whether the distances of the planets from the sun had not some relation to the five regular polyhedrons. This idea contained nothing absurd, but it was sterile, since nature is not so made. Newton has shown us that a law is only a necessary relation between the present state of the world and its immediately subsequent state. All the other laws since discovered are nothing else; they are in sum, differential equations; but it is astronomy which furnished the first model for them, without which we should doubtless long have erred.

Astronomy has also taught us to set at naught appearances. The day Copernicus proved that what was thought the most stable was in motion, that what was thought moving was fixed, he showed us how deceptive could be the infantile reasonings which spring directly from the immediate data of our senses. True, his ideas did not easily triumph, but since this triumph there is no longer a prejudice so inveterate that we can not shake it off. How can we estimate the value of the new weapon thus won?

The ancients thought everything was made for man, and this illusion must be very tenacious, since it must ever be combated. Yet it is necessary to divest oneself of it; or else one will be only an eternal myope, incapable of seeing the truth. To comprehend nature one must be able to get out of self, so to speak, and to contemplate her from many different points of view; otherwise we never shall know more than one side. Now, to get out of self is what he who refers everything to himself can not do. Who delivered us from this illusion? It was those who showed us that the earth is only one of the smallest planets of the solar system, and that the solar system itself is only an imperceptible point in the infinite spaces of the stellar universe.

At the same time astronomy taught us not to be afraid of big numbers. This was needful, not only for knowing the heavens, but to know the earth itself; and was not so easy as it seems to us to-day. Let us try to go back and picture to ourselves what a Greek would have thought if told that red light vibrates four hundred millions of millions of times per second. Without any doubt, such an assertion would have appeared to him pure madness, and he never would have lowered himself to test it. To-day an hypothesis will no longer appear absurd to us because it obliges us to imagine objects much larger or smaller than those our senses are capable of showing us, and we no longer comprehend those scruples which arrested our predecessors and prevented them from discovering certain truths simply because they were afraid of them. But why? It is because we have seen the heavens enlarging and enlarging without cease; because we know that the sun is 150 millions of kilometers from the earth and that the distances of the nearest stars are hundreds of thousands of times greater yet. Habituated to the contemplation of the infinitely great, we have become apt to comprehend the infinitely small. Thanks to the education it has received, our imagination, like the eagle's eye that the sun does not dazzle, can look truth in the face.

Was I wrong in saying that it is astronomy which has made us a soul capable of comprehending nature; that under heavens always overcast and starless, the earth itself would have been for us eternally unintelligible; that we should there have seen only caprice and disorder; and that, not knowing the world, we should never have been able to subdue it? What science could have been more useful? And in thus speaking I put myself at the point of view of those who only value practical applications. Certainly, this point of view is not mine; as for me, on the contrary, if I admire the conquests of industry, it is above all because if they free us from material cares, they will one day give to all the leisure to contemplate nature. I do not say: Science is useful, because it teaches us to construct machines. I say: Machines are useful, because in working for us, they will some day leave us more time to make science. But finally it is worth remarking that between the two points of view there is no antagonism, and that man having pursued a disinterested aim, all else has been added unto him.

Auguste Comte has said somewhere, that it would be idle to seek to know the composition of the sun, since this knowledge would be of no use to sociology. How could he be so short-sighted? Have we not just seen that it is by astronomy that, to speak his language, humanity has passed from the theological to the positive state? He found an explanation for that because it had happened. But how has he not understood that what remained to do was not less considerable and would be not less profitable? Physical astronomy, which he seems to condemn, has already begun to bear fruit, and it will give us much more, for it only dates from yesterday.

First was discovered the nature of the sun, what the founder of positivism wished to deny us, and there bodies were found which exist on the earth, but had here remained undiscovered; for example, helium, that gas almost as light as hydrogen. That already contradicted Comte. But to the spectroscope we owe a lesson precious in a quite different way; in the most distant stars, it shows us the same substances. It might have been asked whether the terrestrial elements were not due to some chance which had brought together more tenuous atoms to construct of them the more complex edifice that the chemists call atoms; whether, in other regions of the universe, other fortuitous meetings had not engendered edifices entirely different. Now we know that this is not so, that the laws of our chemistry are the general laws of nature, and that they owe nothing to the chance which caused us to be born on the earth.

But, it will be said, astronomy has given to the other sciences all it can give them, and now that the heavens have procured for us the instruments which enable us to study terrestrial nature, they could without danger veil themselves forever. After what we have just said, is there still need to answer this objection? One could have reasoned the same in Ptolemy's time; then also men thought they knew everything, and they still had almost everything to learn.

The stars are majestic laboratories, gigantic crucibles, such as no chemist could dream. There reign temperatures impossible for us to realize. Their only defect is being a little far away; but the telescope will soon bring them near to us, and then we shall see how matter acts there. What good fortune for the physicist and the chemist!

Matter will there exhibit itself to us under a thousand different states, from those rarefied gases which seem to form the nebula and which are luminous with I know not what glimmering of mysterious origin, even to the incandescent stars and to the planets so near and yet so different.

Perchance even, the stars will some day teach us something about life; that seems an insensate dream and I do not at all see how it can be realized; but, a hundred years ago, would not the chemistry of the stars have also appeared a mad dream?

But limiting our views to horizons less distant, there still will remain to us promises less contingent and yet sufficiently seductive. If the past has given us much, we may rest assured that the future will give us still more.

After all, it could scarce be believed how useful belief in astrology has been to humanity. If Kepler and Tycho Brahe made a living, it was because they sold to naïve kings predictions founded on the conjunctions of the stars. If these princes had not been so credulous, we should perhaps continue to believe that nature obeys caprice, and we should still wallow in ignorance.

THE PROGRESS OF SCIENCE

THE SMITHSONIAN INSTITUTION AND ITS SECRETARY

The regents of the Smithsonian Institution at their annual meeting on January 23 elected Dr. Charles D. Walcott to succeed the late Samuel Pierpont Langley as secretary of the institution. Born in New York State in 1850, Dr. Walcott became assistant in the Geological Survey of the state in 1876, passing to the U. S. Geological Survey in 1879. In 1894 he succeeded Major Powell as director of the national survey, which under his administration has enjoyed an unprecedented development, the annual appropriation by congress for its work being in the neighborhood of $1,500,000. The survey has been criticized for bureaucratic methods, for trespassing on fields occupied by other geologists and for turning out a vast amount of routine work rather than discoveries of the highest order. To this it is replied that the efficiency of a government bureau, especially one that is rapidly developing, requires adequate business management, that the spirit of cooperation and research in the survey is excellent, that when a new institution develops on a large scale a certain amount of temporary conflict of interests is inevitable, that the standing of geologists in the survey is as high as of those in the universities, that indeed in no single science in any institution in the world are there so many men engaged in scientific research.

When the Reclamation Service was established by the congress, its extensive work in irrigation was placed under the Geological Survey, and it has been carried forward with an efficiency and economy comparing most favorably with the conditions on the Isthmian Canal. When the service was well organized it was separated from the survey. On the organization of the Carnegie Institution, Dr. Walcott became secretary, and was responsible for a large share of the administrative work. He, however, withdrew from this position after Dr. Woodward's election to the presidency. He was also for a short time acting-assistant secretary of the Smithsonian Institution in charge of the National Museum, and has been since 1892 honorary curator of paleontology in the museum.

Dr. Walcott was vice-president of the American Association for the Advancement of Science in 1903, has been president of the Washington Academy of Sciences since 1899 and became a member of the National Academy of Sciences in 1896. He has received the doctorate of laws from Hamilton, Chicago, Johns Hopkins and Pennsylvania. He has become eminent for his researches on the stratigraphy and paleontology of the lower Paleozoic formation and the sedimentation, stratigraphy and contained faunas of the Cambrian formation.

The acceptance of the secretaryship of the Smithsonian Institution involves unusual responsibilities. It is generally regarded as the highest scientific office in the country; indeed it is possible that a too obvious halo has been painted about the head of the secretary. The organization of the institution is such as to give to him great, perhaps undue, powers. The regents are the vice-president and the chief justice of the United States, six congressmen and six citizens. They have, as a rule, met for an hour or two once a year to listen to the report of the secretary; they have neither time nor competence to direct the policy of the institution. The conditions are somewhat similar in many of our universities, but there the faculties have a certain moral control, however limited their statutory rights. So far as appears in the annual reports, there is not a single scientific man, except the secretary, on the Smithsonian foundation, and the scientific men employed in the dependencies are likely to receive the salaries and treatment of departmental clerks. Thus the late secretary could write in his annual report in regard to the Bureau of American Ethnology: 'The actual conduct of these investigations has been continued by the secretary in the hands of Major Powell,' and he could appoint a successor to Major Powell and alter the title from director to chief without the advice of the regents or of any body of scientific experts.

It is well known that a large part of the scientific work under the government had its origin in the Smithsonian Institution, but Henry, the first secretary, was always ready to relinquish work that could be done elsewhere, leaving to the Smithsonian what it only could do. The opposite policy has been followed in recent years, and the National Museum and other agencies supported by the government have not only been kept under the Smithsonian, but have been subordinated to the personal control of the secretary. The propriety of using Smithson's unique bequest for the support of governmental institutions is doubtful, and the result has not been favorable. The National Museum, for example, whether regarded as an educational or research institution, is insignificant when compared with the Museums of Natural History and Fine Arts in New York City, or the similar institutions of foreign nations.

It may be unwise to detach the various governmental agencies from the control of the Smithsonian regents at present, or so long as we have no department of science and education. Directors should, however, be found for the National Museum and other agencies, and scientific men of high standing should be attracted to these institutions, who should be permitted to guide their policies, subject only to the ultimate control of the regents, which should naturally be exercised only on rare occasions and under competent advice. We should like to see the Smithsonian Institution itself devoted to the broad purposes of its foundation 'the increase and diffusion of knowledge among men,' and under existing conditions this could perhaps best be accomplished by some form of cooperation and affiliation between it and the scientific men and scholars of the country and the world.

THE REPORT OF THE PRESIDENT OF THE CARNEGIE INSTITUTION

When the Carnegie Institution was established five years ago, many American men of science hoped that it would fill the position that the Smithsonian Institution had relinquished, and become a center for the higher scientific and intellectual life of the country. But such vague visions are difficult to realize in concrete performance. It is disappointing that the Carnegie Institution has been able to do nothing beyond making grants to certain scientific men and founding certain research institutions along well-established lines, but it may none the less be difficult to say what else it could do to better advantage. Money spent on scientific research is almost surely well spent. If the undertakings of the Carnegie Institution are what in commercial life would be called three-per-cent. investments, in science they bring a material return manyfold as large, and the ideal results are not to be measured.

It is somewhat surprising, therefore, to read in the report of President Woodward that "after careful examination of the facts at hand I think it safe to state that no direct return may be anticipated from more than half of the small grants made up to the present time for minor researches and for research assistantships." There are given in the report the names of forty individuals and institutions which have received minor grants and of six research assistants, and they appear to be of about the same standing and largely the same individuals as those who have received grants in previous years. It is not easy to decide which grants the president refers to in his report, as it might be supposed that every one of them would yield direct returns. The grantees include many of our most eminent men of science, such as Professors S. Newcomb, W. W. Campbell, L. Boss, A. A. Noyes, T. W. Richards, T. C. Chamberlin, R. S. Chittenden, E. L. Mark and E. B. Wilson, and it is inconceivable that money entrusted to them would not be spent to advantage. It is, however, possible that equally good results would have been obtained if twenty of the grants had been distributed by lot among members of the National Academy of Sciences and the other twenty among the fellows of the American Association, and this would have obviated the suspicion of favoritism and indirect influence which is almost inevitable when such largesses depend mainly on the decision of a single individual.

The president recommends that in general minor grants shall be given only to eminent investigators who shall for the time become research associates and advisers of the institution. That the institution needs a board of scientific men is obvious. Its trustees, as is usual in America, consist mainly of prominent men of affairs, most of whom are too busy to give attention to the control of the institution, even if they were competent to do so. The secretary, originally an eminent resident man of science, is now a business man of New York City. The by-laws speak of special advisers and advisory committees, but if such exist they are not mentioned in the annual report. The only possible reference in the by-laws to the scientific men who should be the institution is a clause to the effect that the president 'shall have power to remove and appoint subordinate employees.' If the trustees could fulfil their proper function in the care of the property, and the president could be a constitutional executive officer, and there were a legislative board consisting of scientific men, elected by the scientific bodies of the country, a great advance in organization would be effected. Perhaps we may hope that the advisers nominated by the president may ultimately become a board of this character.

The larger projects of the institution last year were: botanical research, D. T. MacDougal, director; economics and sociology, Carroll D. Wright, director; experimental evolution, Charles B. Davenport, director; historical research, J. F. Jameson, director; horticulture, Luther Burbank; marine biology, A. G. Mayer, director; meridian astrometry, Lewis Boss, director; nutrition, F. G. Benedict, R. H. Chittenden, L. B. Mendel and T. B. Osborne; solar physics, George E. Hale, director; terrestrial magnetism, L. A. Bauer, director; work in geophysics, F. D. Adams, G. F. Becker, A. L. Day. For these departments the sum of $552,000 was appropriated, the largest grants being: Solar Observatory, $150,000; geophysical research, $115,500, and terrestrial magnetism, $54,000. Appended to the president's report are extremely interesting accounts of the research work accomplished under the large projects and minor grants. Illustrations showing the site of the solar observatory and the laboratories for experimental and marine biology are here reproduced.

MR. ROCKEFELLER'S GIFT TO THE GENERAL EDUCATION BOARD

Mr. John D. Rockefeller has announced his intention to give, not later than April 1, securities valued at about

$32,000,000, to the General Education Board, which he had previously endowed with $11,000,000. The letter announcing this gift, read at a meeting of the board on February 7, is as follows:

New York, Feb. 6, 1907.
General Education Board,
54 William Street,
New York City.

Gentlemen: My father authorizes me to say that on or before April 1, 1907, he will give to the General Education Board income-bearing securities, the present market value of which is about thirty-two million dollars ($32,000,000), one third to be added to the permanent endowment of the board, two thirds to be applied to such specific objects within the corporate purposes of the board as either he or I may, from time to time, direct; any remainder not so designated at the death of the survivor to be added also to the permanent endowment of the board.

Very truly,
JOHN D. ROCKEFELLER, JR.

The board has acknowledged this great gift in the following terms:

The General Education Board acknowledges the receipt of the communication of February 6, 1907, from Mr. John D. Rockefeller, Jr., a member of this body, announcing your decision to give to the board for the purpose of its organization, securities of the current value of $32,000,000. The General Education Board accepts this gift with a deep sense of gratitude to you and of responsibility to society. This sum, added to the $11,000,000 which you have formerly given to this board, makes the General Education Board the guardian and administrator of a total trust fund of $43,000,000.

This is the largest sum ever given by a man in the history of the race for any social or philanthropic purpose. The board congratulates you upon the high and wise impulse which has moved you to this deed, and desires to thank you, in behalf of all educational interests whose developments it will advance, in behalf of our country whose civilization for all time it should be made to strengthen and elevate, and in behalf of mankind everywhere, in whose interests it has been given and for whose use it is dedicated.

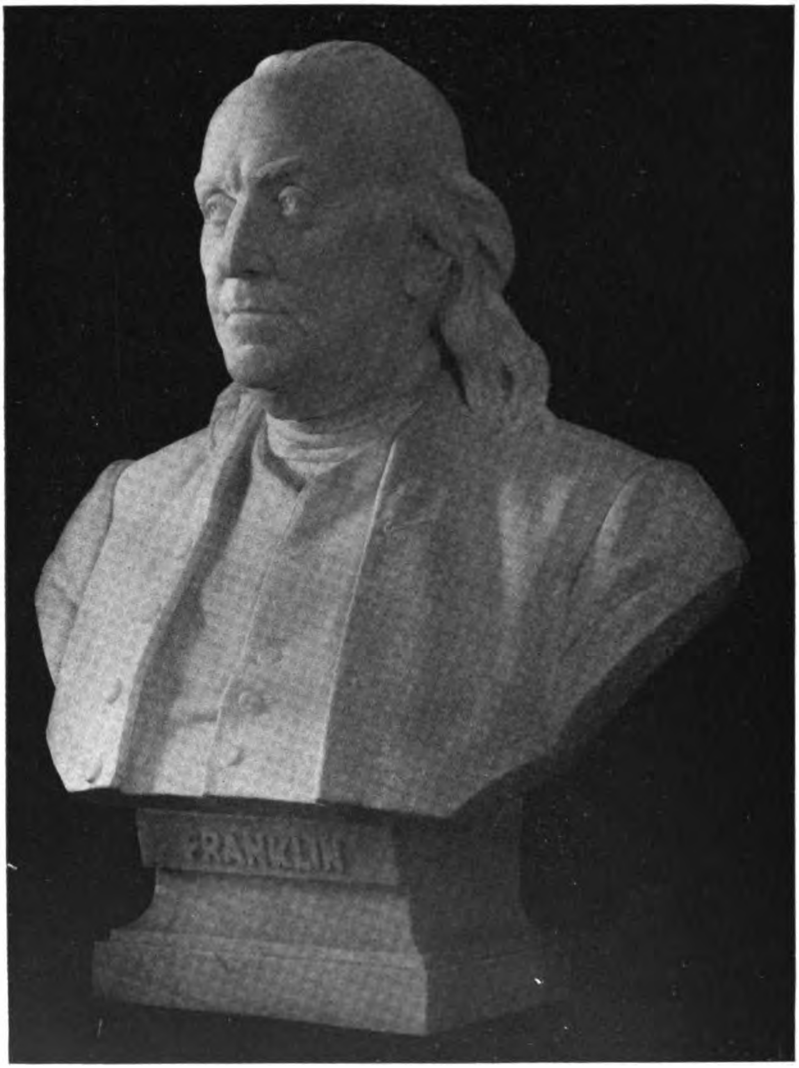
The administration of this fund entails upon the General Education Board the most far-reaching responsibilities ever placed upon any educational organization in the world. As members of the board, we accept this responsibility, conscious alike of its difficulties and its opportunities.

We will use our best wisdom to transmute your gift into intellect and moral power, accounting it a supreme privilege to dedicate whatever strength we have to its just use in the service of men.

The work of the General Education Board has in the main been confined to gifts to certain denominational colleges on condition that they collect three times the amount appropriated, but the present gift is not limited to higher education. It is said that agricultural education in the south will be especially assisted. It will be observed that Mr. Rockefeller and his son reserve the right to dispose of two thirds of the capital in accordance with the purposes of the board. This is a wise provision, as the money would probably be of greatest use if distributed to assist existing institutions without other conditions than their deserts, or to establish new institutions. A centralized control of higher education, however indirect, has dangers as well as advantages.

SCIENTIFIC ITEMS

M. CHAUVEAU, of the section of agriculture, has been elected president of the Paris Academy of Sciences to succeed M. Poincaré, of the section of mathematics.—Professor Ernest W. Brown, who this year goes from Haverford College to Yale University, has been awarded the Adams prize of Cambridge University, for his work on the motion of the moon.—Professor William James, of Harvard University, our most eminent student of philosophy and psychology, celebrated his sixty-fifth birthday on January 11, and retired on January 22 from the active work of his chair.


FRANKLIN

THE POPULAR SCIENCE MONTHLY

APRIL, 1907

PIONEERS OF SCIENCE IN AMERICA[1]

BENJAMIN FRANKLIN

BY DR. S. WEIR MITCHELL

PHILADELPHIA, PA.

WE are here, as I understand, to unveil memorial busts of Americans distinguished in science. I, Sir, am honored by the privilege of speaking of Benjamin Franklin. This man, the father of American Science, was possessed of mental gifts unequaled in his day. Even yet he holds the highest place in the intellectual peerage of a land where, in his time, men had few interests which were not material or political. But no man entirely escapes the despotic influences of his period. Thus in every life there are unfulfilled possibilities, and so it was that, paraphrasing Goldsmith, we may say that Franklin to country gave up what was meant for mankind, when with deep regret he resigned, in middle life, all hope of whole-souled devotion to science. When most productive his scientific fertility was the more remarkable because of the other forms of dutiful activity which in a life that knew no rest left small leisure for those hours of quiet thought without which science is unfruitful of result.

[1] There were unveiled at the American Museum of Natural History, New York City, on December 29, ten marble busts of American men of science, designed by Mr. William Couper and presented by Mr. Morris K. Jesup, the president of the museum. The occasion was arranged in honor of the American Association for the Advancement of Science and the affiliated societies meeting at the time in New York City. The exercises took place in the presence of a distinguished audience that crowded the large lecture hall of the museum. By the courtesy of the director of the museum, Dr. Hermon C. Bumpus, we are able to print here the addresses given in connection with the unveiling and photographs of the busts.—EDITOR.

There is a Hall of Fame not built by the hand of man. It is the memory of mankind. In many of its galleries this man's bust could with justice be placed. Diplomacy would claim him as of her greatest. For him would be the laurel of administrative wisdom. Among statesmen he would be welcomed; and who of the masters of English prose shall in that hall of fame be more secure of grateful remembrance, and who more certain of a place among men of science.

As an investigator of nature and of nature's laws he is materially represented here by right of eminent achievement. Let us as men of science feel proud that Franklin's fame as a philosopher did much to win for Franklin the diplomatist such useful consideration and respect as led to final success.

Many of those you honor to-day had moral and temperamental peculiarities which more or less influenced their lives and are common to men of science. Most of them cared little about making money; still less about keeping it. Franklin, on the contrary, dreaded poverty; was careful in business, made fruitful investments and died rich; nevertheless, like the typical man of science, he refused to make money out of his discoveries, or by patents to protect his inventions. In him the man of science, unselfish, free from money greed, seemed to exist apart from all those other men who went to the making of the many-minded Franklin. In another way he was singularly unlike such typical men of science as Henry, in physics, and Leidy, in natural history. When Franklin made a discovery his next thought was as to what practical use it could be put. If he made some novel observation of nature, he asked himself at once how he could make it serve his fellow men. The great reapers of the harvest of truth commonly leave the inventor to make practical use of their unregarded thought.

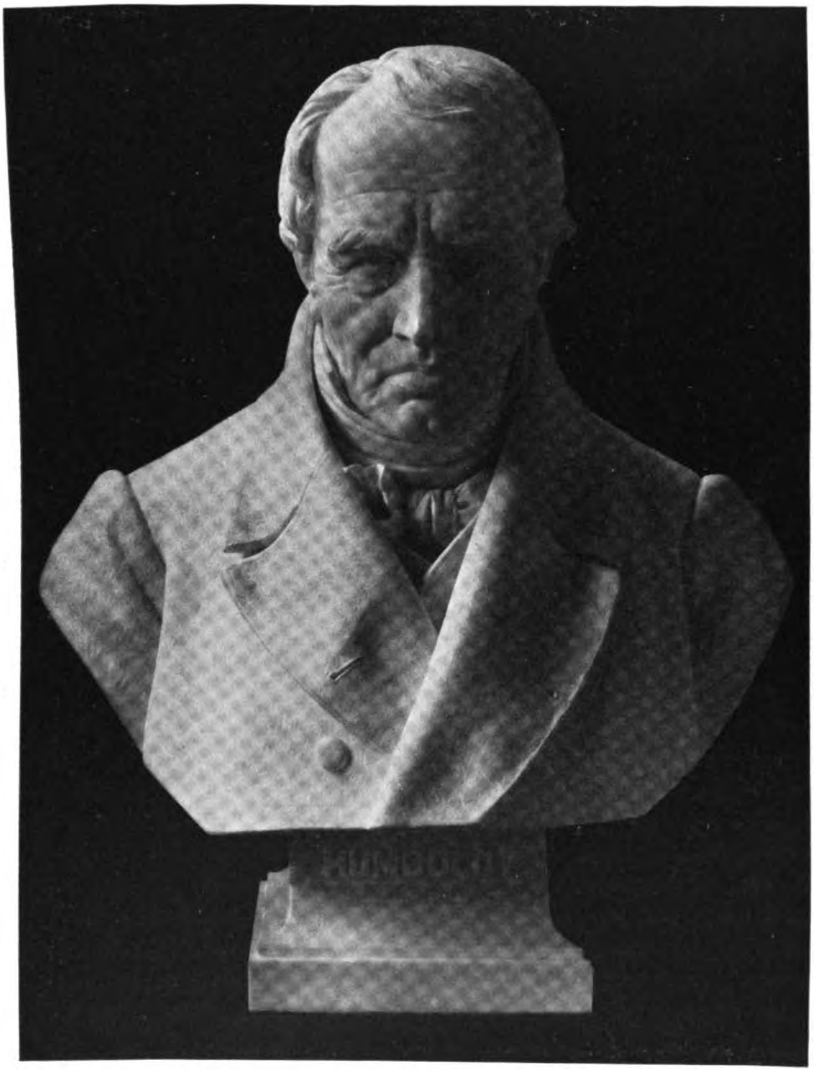
Leaving the wide land to do justice to Franklin, the model citizen and great diplomatist, here we crown him with the assured verdict of posterity Franklin, the man of pure science. Here we welcome him to this goodly fellowship of those who communed with nature and read the secrets of the Almighty Maker.

Alexander von Humboldt

By Baron SPECK VON STERNBURG

GERMAN EMBASSY, WASHINGTON, D. C.

In this immortal man, whose bust you have gathered to unveil, the world reveres its greatest master since the days of Aristotle. His genius covered all that man ever thought, did and observed in nature. There is no branch of human knowledge into which his mind did not



penetrate. His Cosmos, that marvelous monument of meditation and research, is a new book of Genesis in which the universe mirrors itself in all its vastness and minuteness 'from the nebulæ of the stars'—to use his own words—'to the geographical distribution of mosses on granite rocks.'

By his wonderful talent of research, by his almost superhuman power to divine eternal laws, this great interpreter of science taught mankind how to read in the book of nature, how to understand its great mysteries. The series of sciences, originated by this mighty genius is, as well as the other manifold branches of science developed by him, sufficiently known to all of you.

In all his investigations his ultimate aim was to bring theory into practical relation with life. Thus he not only elevated the standard of culture of the whole world by many steps, but he also became from a practical point of view the benefactor of mankind in many branches of common life, as trade, commerce, navigation.

He taught us how to conceive the beauty and sublimity of nature in its every form and motion. His studies are not a matter merely of memory and of dry meditation, to him nature was rather the inexhaustible source of pure and deep enjoyment, by which the heart is purified and ennobled and men are brought nearer to perfection.

It is not necessary to give you a more detailed picture of his life. All this is so well known and so dear to the whole learned world of America; for never has a foreign scholar been more honored in this country than Alexander von Humboldt.

We need only recall the celebrations which took place in his memory, both at the time of his death and on occasion of the centennial anniversary of his birth, when throughout all America solemn offerings of gratitude and devotion went out to the shadow of the great dead.

Humboldt devoted five years of his life to scientific investigations in South and Central America, in Mexico and in Cuba. He ascertained the course of the greatest rivers, he climbed the summits of mountains, where never man's foot had trod before, he studied vegetation, astronomical and meteorological phenomena, gathered specimens of all natural products and a great deal of historical information about the early population of these parts of the New World. It was he that drew the first accurate maps of these regions. With almost prophetic forecast of the needs of generations to come, he examined the Isthmus of Panama and considered carefully the possibilities of establishing an interoceanic waterway.

It is well known how great an interest Alexander von Humboldt has taken in the United States. Indeed, so strongly was he attracted by the problems of the new-born republic that, putting aside even his habitual scientific occupations, he devoted himself entirely for some months to the study of the American people and the institutions of this country.

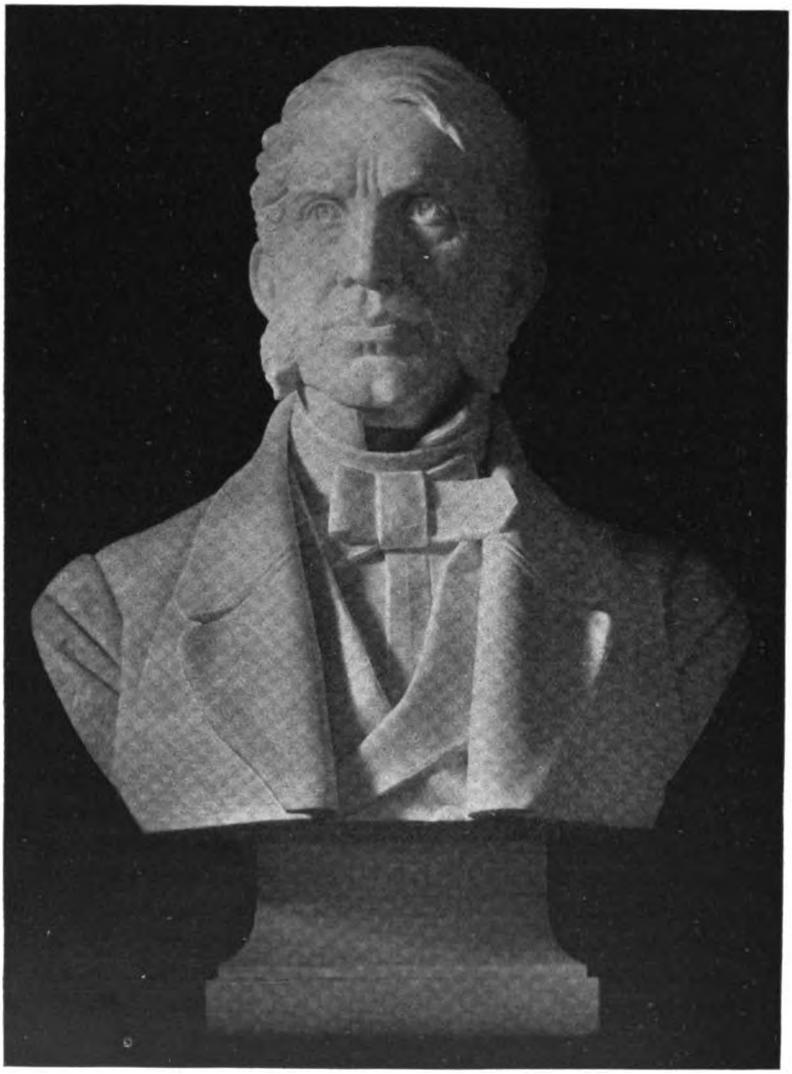
Finally, the great scientist, he whom people call the scientific discoverer of America, returned to his country, carrying with him a vast store of intellectual and material treasures of science. So abundant were the results reaped from his expeditions that he needed the cooperation of the best scholars of his time to compile that great mass of material, and to place it into proper shape and form.

Throughout his long and industrious life, Alexander von Humboldt has ever retained his love and devotion for the country where his great field of labor lay, and for its people to whom he always felt so closely connected by his love for freedom in thoughts and for liberty. It is a well-known fact that in his later days of all foreign people who ever knocked at his door no one was more heartily welcomed than the American citizen.

The benefits of his investigations in America returned to that country in the course of time. No wonder that her people recognize him as their benefactor. Another great man, whose monument will be unveiled to-day, and most deservedly placed beside the one of Alexander von Humboldt, Louis Agassiz, says of him: "To what degree we Americans are indebted to von Humboldt, no one knows who is not familiar with the history of learning and education in this country. All the fundamental facts of popular education in physical science beyond the merest elementary instruction, we owe to him," and at another place: "Let us rejoice together that Humboldt's name will permanently be connected with education and learning in this country, for the prospects and institutions of which he felt so deep and so affectionate a sympathy."

Of all the tributes that have been paid to Alexander von Humboldt the latest and most fitting has now found its expression in this building. For here, in this magnificent Museum of Natural History, the ideal aim of all his theories is realized most perfectly: to cultivate the love of nature, and thus to ennoble man and beautify his life.

Gentlemen, permit me to thank you for the honor you have done me to-day, and to express the hope that this splendid building may become a shrine of pilgrimage for scientists and students also of the Old World, helping to bind the nations closer together.



John Torrey

Dr. N. L. Britton
DIRECTOR OF THE NEW YORK BOTANICAL GARDEN

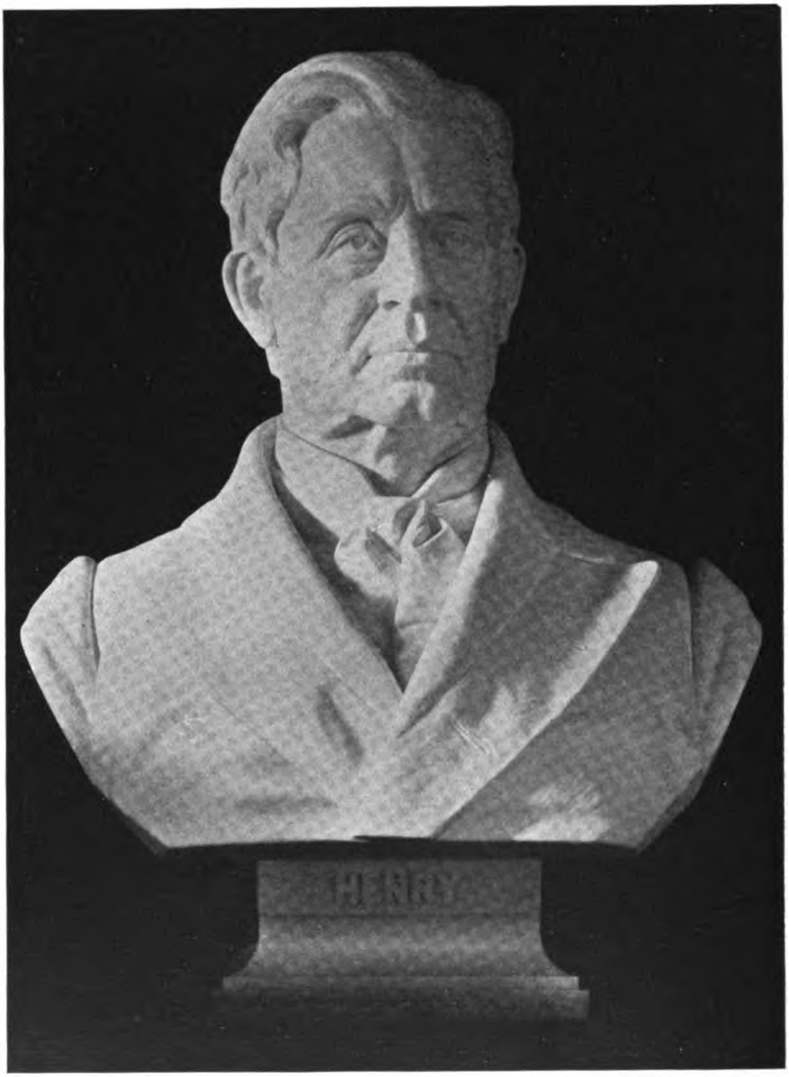
As a pioneer of American botany, John Torrey naturally finds a place among the men whose works we gladly celebrate to-day, in this grand institution, developed in the city where he was born, where he resided the greater part of his life, and where he died. To-day's recognition of Torrey as a master of botanical science is, therefore, peculiarly appropriate in New York, where he is already commemorated by the society which bears his name, by the professorship in Columbia University named in his honor, and by his botanical collections and library deposited by Columbia University at the New York Botanical Garden.

Dr. Torrey was born on August 15, 1796, and died March 10, 1873, nearly thirty-four years ago; the pleasure of his personal acquaintance is, therefore, known to but few persons now living; we have abundant evidence, however, that he was honored and beloved to a degree experienced by but few; righteousness was instinctive in him, aid to others was his pleasure, he was tolerant and progressive, and his genial presence was a delight to his associates.

He was educated for the profession of medicine, graduating from the College of Physicians and Surgeons in 1818, but soon abandoned it and in 1824 became professor of chemistry at West Point; after three years service there, he was elected professor of chemistry and botany in the College of Physicians and Surgeons, a position which he held for nearly thirty years, during part of this period lecturing on chemistry also at Princeton; he was also United States assayer in New York from 1854 until his death.

Dr. Torrey's attention was directed to botany during his youthful association with Professor Amos Eaton, and his interest in that science subsequently stimulated during his medical studies by the lectures of Professor David Hosack. It early became his favorite study, and, notwithstanding his noteworthy services to chemistry, his fame rests on his botanical researches, although they were accomplished durng his hours of rest and recreation, and largely during the night.

His botanical publications began in 1819 with 'A Catalogue of Plants Growing Spontaneously within Thirty Miles of the City of New York,' published by the Lyceum of Natural History, now the New York Academy of Sciences, and were completed the year after his death in the 'Phanerogamia of Pacific North America,' in Vol. 17 of the Report of the United States Exploring Expedition. His contributions to botany include over forty titles, many of them volumes requiring years of patient study; they throw a flood of light on the


HENRY

plants of North America, and form a grand contribution to knowledge. His collections, on which these researches are based, were annotated and arranged by him with scrupulous care and exactness, and are treasured as among the most important of all scientific material in America.

JOSEPH HENRY

BY DR. ROBERT S. WOODWARD

THE CARNEGIE INSTITUTION

This time, one hundred years ago, Joseph Henry, whose name and fame we honor to-day, was a lad seven years of age. He was born at Albany, New York, of Scotch parentage, his grandparents on both sides having come from Scotland in the same ship to the Colony of New York, in 1775.

Doubtless he had himself in mind when in his mature years he affirmed that "The future character of a child, and that of a man also, is in most cases formed probably before the age of seven years." At any rate, he found himself early, for at the age of sixteen he had determined to devote his life to the acquisition of knowledge. Thus be became, in turn, student, teacher, civil engineer in the service of his native state, professor of mathematics and natural philosophy in the Albany Academy, professor of natural philosophy in the College of New Jersey—now Princeton University—and a pioneer investigator and discoverer of the first order before he was thirty-three years of age.

His inventions and discoveries in electromagnetism especially are of prime importance. They include the inventions of the electromagnetic telegraph and the electromagnetic engine, and the discovery of many of the recondite facts and principles of electromagnetic science.

From the age of thirty-three, when he took up the work of his professorship at Princeton, till the age of forty-seven, when he was called to the post of secretary of the Smithsonian Institution, he pursued his original investigations with untiring zeal and with consummate experimental skill and philosophic insight. It was during this period that Henry and Faraday laid the foundations for the recent wonderful developments of electromagnetic science. The breadth as well as the depth of Henry's learning is indicated by the fact that he found time during this busy period for excursions and for lectures in the fields of architecture, astronomy, chemistry, geology, meteorology and mineralogy, in addition to his lectures and researches in physics.

He was a man rich in experience and ripe in knowledge when, in 1846, he assumed the administative duties implied by the bequest of James Smithson. "To found at Washington, under the name of the

Smithsonian Institution an Establishment for the increase and diffusion of knowledge among men." Henceforth, for thirty-two years, until his death in 1878, he devoted his life to the public service, not alone of our own country, but of the entire civilized world. In this work he manifested the same creative capacity that had distinguished his earlier career in the domain of natural philosophy. He became an organizer and a leader of men. To his wise foresight we owe not only the beneficent achievements of the Smithsonian Institution itself, but also, in large degree, the correspondingly beneficent achievements of the Naval Observatory, the Coast and Geodetic Survey, the Weather Bureau, the Geological Survey, the Bureau of Fisheries and the Bureau of American Ethnology; for to Henry, more than to any other man, must be attributed the rise and the growth in America of the present public appreciation of the scientific work carried on by governmental aid.

We may lament, with John Tyndall, that so brilliant an investigator and discoverer as Henry should have been sacrificed to become so able an administrator. And American devotees to mathematico-physical science may be pardoned for entertaining an elegaic regret that Henry as a pioneer in the fields of electromagnetism did not have the aid of a penetratng mathematical genius, as Faraday had his Maxwell. But posterity, just in its estimtes towards all the world, will recognize in Henry, as we have recognized in our earlier hero, Benjamin Franklin, a many-sided man—a profound student of nature; a teacher whose moral and intellectual presence pointed straight to the goal of truth; an inventor who dedicated his inventions immediately to the public good; a discoverer of the permanent laws which reign in the sphinx-like realm of physical phenomena; an administrator and organizer of large enterprises which have yielded a rich fruitage for the enlightenment and for the melioration of mankind; a leader of men devoted to the progress of science; a patriot, friend and counsellor of Abraham Lincoln in the darker days of the republic —in short, an exemplar for his race, a man whose purity and nobility are here fitly symbolized in enduring marble for our instruction and guidance and for the instruction and the guidance of our successors in the centuries to come.

JOHN JAMES AUDUBON

BY DR. C. HART MERRIAM
U. S. BIOLOGICAL SURVEY

Of the naturalists of America no one stands out in more picturesque relief than Audubon, and no name is dearer than his to the hearts of the American people.

Born at an opportune time, Audubon undertook and accomplished one of the most gigantic tasks that has ever fallen to the lot of one man to perform. Although for years diverted from the path nature intended him to follow, and tortured by half-hearted attempts at a commercial life, against which his restive spirit rebelled, he finally, by the force of his own will, broke loose from his bondage and devoted the remainder of his days to the grand work that has made his memory immortal.

His principal contributions to science are his magnificent series of illustrated volumes on the birds and quadrupeds of North America, his Synopsis of Birds and the Journals of his expeditions to Labrador and to the Missouri and Yellowstone rivers.

The preparation and publication of his elephant folio atlases of life-size colored plates of birds, begun in 1827 and completed in 1838, with the accompanying volumes of text (the 'Ornithological Biography,' 1831–1839), was a colossal task. But no sooner was it accomplished than an equally sumptuous work on the mammals was undertaken, and, with the assistance of Bachman, likewise carried to a successful termination. For more than three quarters of a century the splendid paintings which adorn these works, and which for spirit and vigor are still unsurpassed, have been the admiration of the world.

In addition to his more pretentious works, Audubon wrote a number of minor articles and papers and left a series of Journals, since published by his granddaughter, Miss Maria R. Audubon. The Journals are full to overflowing with observations of value to the naturalist, and, along with the entertaining 'Episodes,' throw a flood of light on contemporary customs and events—and incidentally are by no means to be lost sight of by the historian.

In searching for material for his books, Audubon traveled thousands of miles afoot in various parts of the eastern states, from Maine to Louisiana; he also visited Texas, Florida and Canada, crossed the ocean a number of times, and conducted expeditions to far-away Labrador and the then remote Missouri and Yellowstone Rivers. When we remember the limited facilities for travel in his day—the scarcity of railroads, steamboats and other conveniences—we are better prepared to appreciate the zeal, determination and energy necessary to accomplish his self-imposed task.

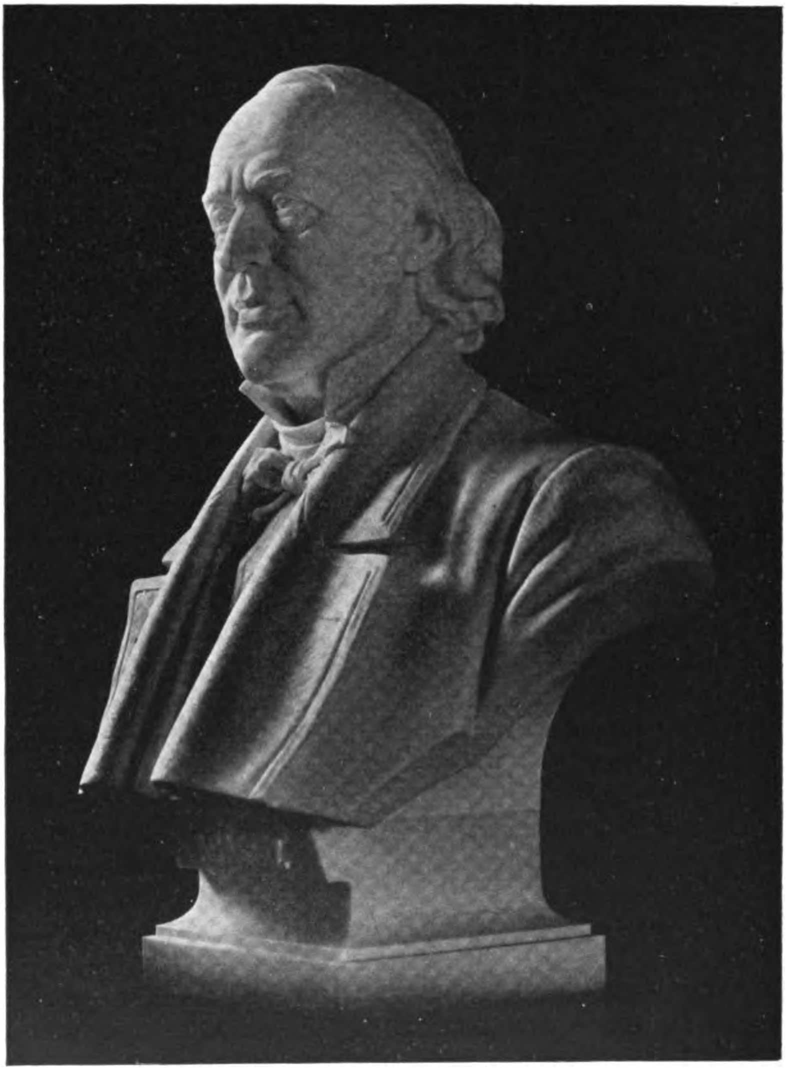
That it was possible for one man to do so much excellent field work, to write so many meritorious volumes, and to paint such a multitude of remarkable pictures must be attributed in no small part to his rare physical strength—for do not intellectual and physical vigor usually go hand in hand and beget power of achievement? Audubon was noted for these qualities. As a worker he was rapid, absorbed and ardent; he began at daylight and labored continuously till night, averaging fourteen hours a day, and, it is said, allowed only four hours for sleep.

In American ornithology, in which he holds so illustrious a place, it was not his privilege to be in the strict sense a pioneer, for before him were Vieillot, Wilson and Bonaparte; and contemporaneous with him were Richardson, Nuttall, Maximilian, Prince of Wied, and a score of lesser and younger lights—some of whom were destined to shine in the near future.

Audubon was no closet naturalist—the technicalities of the profession he left to other—but as a field naturalist he was at his best and had few equals. He was a born woodsman, a lover of wild nature in the fullest sense, a keen observer, an accurate recorder, and, in addition, possessed the rare gift of instilling into his writings the freshness of nature and the vivacity and enthusiasm of his own personality.

His influence was not confined to devotees of the natural sciences, for in his writings and paintings, and in his personal contact with men of affairs, both in this country and abroad, he exhaled the freshness, the vigor, the spirit of freedom and progress of America—and who shall attempt to measure the value of this influence to our young republic?

Audubon's preeminence is due, not alone to his skill as a painter of birds and mammals, nor to the magnitude of his contributions to science, but also to the charm and genius of his personality—a personality that profoundly impressed his contemporaries, and which, by means of his biographies and journals, it is still our privilege to enjoy. His was a type now rarely met—combining the grace and culture of the Frenchman with the candor, patience, and earnestness of purpose of the American. There was about him a certain poetic picturesqueness and a rare charm of manner that drew people to him and enlisted them in his work. His friend, Dr. Bachman, of Charleston, tells us that it was considered a privilege to give to Audubon what no one else could buy. His personal qualities and characteristics appear in some of his minor papers—notably the essays entitled 'Episodes.' These serve to reveal, perhaps better than his more formal writings, the keenness of his insight, the kindness of his heart, the poetry of his nature, the power of his imagination, and the vigor and versatility of his intellect.



Louis Agassiz [1]

By the Rev. EDWARD EVERETT HALE
BOSTON, MASS.

I think that the first time when I ever saw Agassiz was at one of his own lectures early in his American life. This was a description of his ascent of the Jungfrau. I think it was wholly extempore and though he was new in his knowledge of English, it was idiomatic and thoroughly intelligible. At the end, as he described the last climb, hand and foot, by which as it seems, men come to the little triangular plane, only three feet across, which makes the summit, he quickened our enthusiasm by describing the physical struggle by which he lifted himself so that he could stand on this little three-foot table: He said, 'one by one we stood there, and looked down into Swisserland.' He bowed and retired.

I know I said at once that Mr. Lowell, of our Lowell Institute, who had 'imported Agassiz' (that is James Lowell's phrase), might have said before the audience left the hall, 'You will see, ladies and gentlemen, that we are able to present to you the finest specimen yet discovered of the genus homo of the species intelligens.'

And looking back half a century, on those very first years of his life in America, I think it is fair to say that wherever he went he awakened that sort of personal enthusiasm. And he went everywhere. He was made a professor in Harvard College in 1848. But he never thought of confining himself to any conventional theory of a college professor's work. He was not in the least afraid of making science popular. He flung himself into any or every enterprise by which he could quicken the life of the common schools, and in forty different ways he created a new class of men and women. Naturalists showed themselves on the right hand and on the left. I have seen him address an audience of five hundred people, not twenty of whom when they entered the hall thought they had anything to do with the study of nature. And when after his address they left the hall, all of the five hundred were determined to keep their eyes open and to study nature as she is. From that year 1848, you may trace a steady advance in nature study in the New England schools.

That is to say, that his distinction is that of an educator quite as much as it is that of a naturalist. In 1888, Lowell said, in his quarter-millenial address at Harvard College, that the college trained no great educator, 'for we imported Agassiz.' A great educator he truly was.

When Agassiz was appointed professor he was forty-one years old. In my first personal conversation with him he told me a story, which

[1] A letter read by Professor A. E. Verrill, of Yale University. Interesting remarks were also made by Dr. Charles D. Walcott, Washington, D. C.

may not have got into print, of his own physical strength. He spoke as if it were then an old experience to him. Whether he were twenty-five or thirty-five when it happened, it shows how admirable was his training and his physical constitution. He had been with a party of friends somewhere in eastern Switzerland. They were traveling in their carriages; he was on foot. They parted with the understanding that they were to meet in the Tyrol, at the city of Innsbruck. Accordingly the next morning, Agassiz rose early and started through the mountains by this valley and that, as the compass might direct or his previous knowledge of the region. He did not mean to stop for study and they did not. But he had no special plan as to which hamlet or cottage should cover him at night. Before sundown he came in sight of a larger town than he expected to see, in the distance, and calling a mountaineer, he asked him what that place was. The man said it was Innsbuck. Agassiz said that that could not be so. The man replied with a jeer that he had lived there twenty years, and had always been told that that was the name of the place, but he supposed Agassiz knew better than he did. Accordingly Agassiz determined that he would sleep there and did so. The distance was somewhere near seventy miles. I know it gave me the impression of a walk through the valley passes at the rate of four miles an hour, maintained for sixteen or seventeen hours.

In later life Agassiz made to us some prophecies in which we may trace his enjoyment of the finest physical health and strength. Health and strength indeed belonged to everything which he said and did.

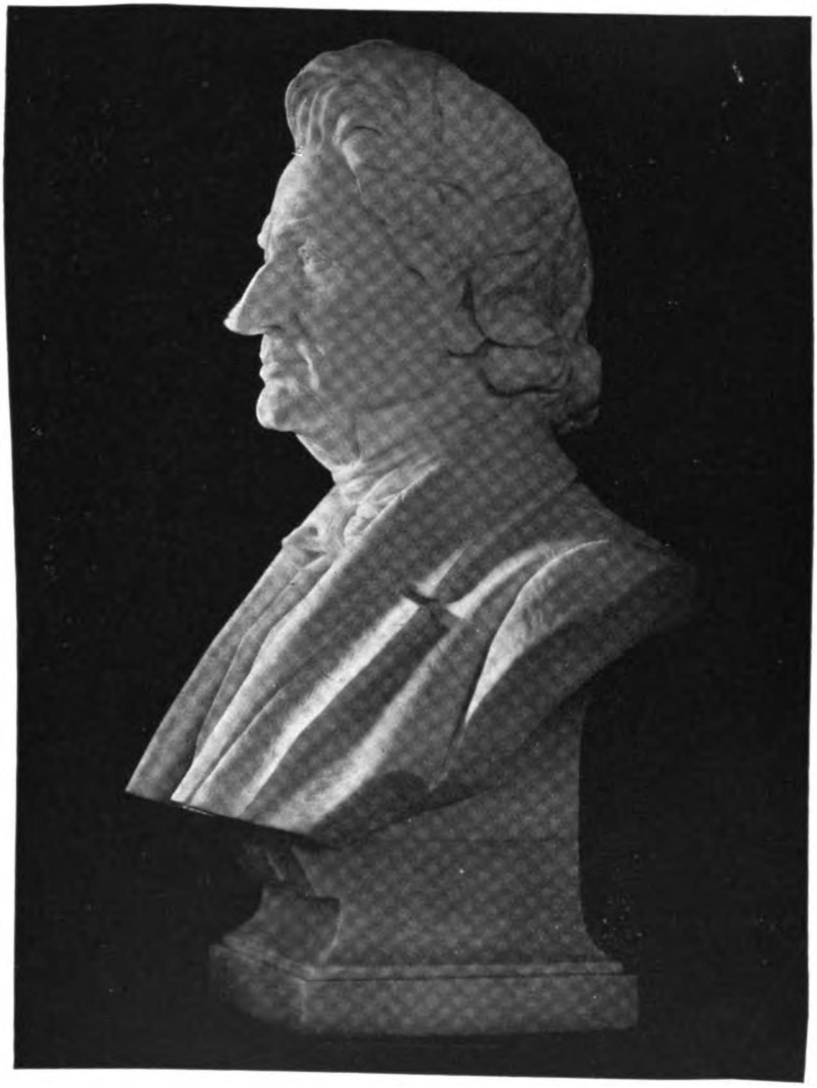
Among other things he said, twenty-five years ago, that the last years of our century—the twentieth—would see a population of a hundred million of people in the valleys of the upper Amazon. I like to keep in memory this brave prophecy because I am sure it will come true.

James Dwight Dana

By President ARTHUR T. HADLEY
YALE UNIVERSITY

It was my privilege to know James Dwight Dana intimately during my early years. To boyhood's imagination his figure typified the man of science; his life personified the spirit of scientific discovery. Wider acquaintance with the world has not in any way dimmed the brightness of that early impression.

The services of the geologist are to-day recognized by every one, and sought by all who can afford them. If he would make a voyage of exploration and discovery, the resources of the world of finance are placed at his disposal. No such aids were given two generations ago.



In Dana's journeyings he had to surmount hardship and peril, and to meet the coldness of those who knew not the value of the quest which he pursued. He and his contemporaries were like the knights errant of chivalry, devoting their lives to an ideal. They were men of faith, who combined the spirit of the missionary and the inspiration of the poet with the clear vision of the observer.

The largeness of Dana's work was commensurate with the largeness of his inspiration. It fell to his lot not only to fill out many pages of the record of the building of the world, as written in the fossil life of America, but to show in important ways the methods by which that building was accomplished. His creative brain never rested content with mere description of facts. He had the more distinctively modern impulse to reconstruct the process by which those facts were brought to pass. From his observations of coral islands in the various stages of their growth he deduced a geologic principle of world-wide importance. It is this characteristic which makes the great modern German school of geologists headed by Suess look to Dana as their precursor, more than to any other man of his generation.

He was not content with the work of discovery alone. The teaching spirit was strong within him. The pioneers in science needed editors and expositors who should make their results known. In each of these capacities Dana's achievements were phenomenal. Of his work as an editor, he has left the files of *The American Journal of Science* as a monument. Of his work as an expositor those who have heard his lectures and attended his class-room exercises can speak with unbounded enthusiasm. He was one of the rare men who by presence and voice and manner could bring the truths and ideals of science home even to those pupils with whom scientific study could never be more than an incident in their lives.

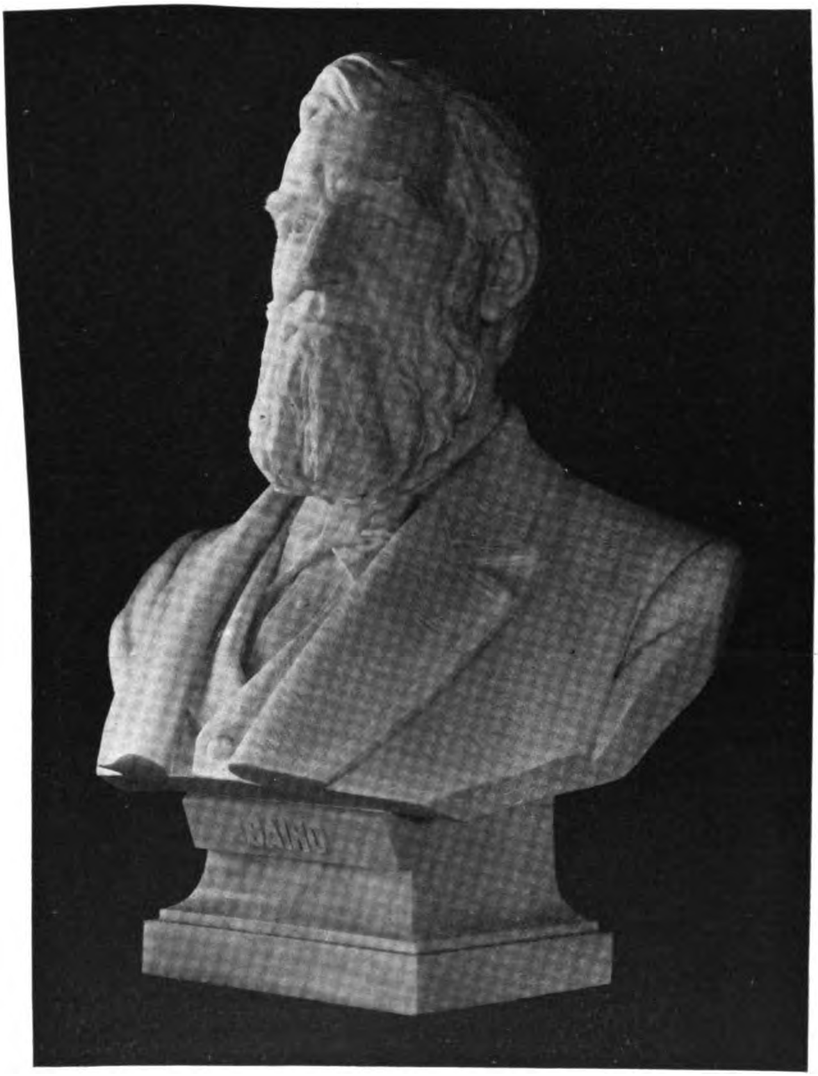
But above all his works and above all his qualities stands the figure of Dana himself—more than an explorer, more than a discoverer, more than a teacher; his countenance, as it were, illuminated by a touch of the light of a new day for which the world was being prepared.

> His life was gentle; and the elements
> So mixed in him that Nature might stand forth
> And say to all the world, 'This was a man.'

Spencer Fullerton Baird

By Dr. HUGH M. SMITH
BUREAU OF FISHERIES

The life, the character, the work of Spencer Fullerton Baird entitle him to recognition in any assemblage and on any occasion where honor is to be paid to those who have been their country's benefactors through illustrious achievements in science.



Developing a taste for scientific pursuits at a very early age, and confirmed in those pursuits through the influence of friendships with Agassiz, Audubon, Dana and other leading scientists of the time, Baird was selected as assistant secretary of the Smithsonian Institution when only twenty-seven years old, and there entered on a career devoted to the promotion, diffusion, and application of scientific knowledge among men, and marked by dignity, sound judgment, fidelity to duty, versatility and general usefulness.

In the many phases of his intellectual development he resembled Franklin and Cope; in the multiplicity of his public duties and in the diversity of the scientific accomplishments in which he attained eminence he had few equals; in founding, organizing and simultaneously directing a number of great national scientific enterprises he was unique among those whose memory is here extolled to-day.

To render an adequate account of the branches of scientific endeavor in which he achieved prominence, benefited his own and future generations and added to his country's renown, one would need to be an ornithologist, a mammalologist, an ichthyologist, a herpetologist, an invertebrate zoologist, an anthropologist, a botanist, a geologist, a paleontologist, a deep-sea explorer, a fishery expert, a fish-culturist, an active administrator of scientific institutions, and an adviser of the federal government in scientific affairs; for Baird was all these and more.

We freely acknowledge to-day the debt that science owed Baird alive and now owes his memory, especially for his inestimable services as assistant secretary and later as secretary of the Smithsonian Institution, as director of the National Museum, and as head of the Commission of Fish and Fisheries. Among all the establishments with which he was connected, this last was preeminently and peculiarly his own. It was conceived by him and created for him, and it would almost appear that he was created for it, for certainly no other person of his day and generation was so admirably fitted for the task of organizing this bureau and of executing the duties that grew out of its functions as successively enlarged by congress. Insisting on scientific investigations and knowledge as the essential basis for all current and prospective utilitarian work, he drew around him a corps of eminent biologists and physicists; he established laboratories; he laid plans for the systematic study of our interior and coastal waters; he had vessels built that were especially designed and equipped for exploration of the seas. While he thus inaugurated operations which have been of lasting benefit to the fisheries, at the same time he became the foremost promoter and exponent of marine research, and the knowledge we to-day possess of oceanic biology and physics is directly or indirectly due to Baird more than to any other person. The rapid development of piscicultural science under his guidance gave to the United States the foremost place among the nations in maintaining and increasing the aquatic food supply by artificial means; and it was no perfunctory tribute when, in 1880, at the International Fishery Exhibition held in Berlin, Emperor William awarded the grand prize to Baird as 'the first fish-culturist in the world.'

The spirit of Baird influences the Bureau of Fisheries to-day, as it does all other institutions with which he was associated; and since his death, nearly twenty years ago, the good that has been accomplished in the interest of fish-culture and the fishing industry, and in the conduct and encouragement of scientific work, has been in consequence of the foundations he laid, the policy he enunciated and the example he set.

But conspicuous as were his services to science and mankind; faithful and unselfish as was his devotion to the executive responsibilities imposed on him; beautiful as was his personal character, I conceive that his most enduring fame may result from the enthusiasm with which he inspired others and the encouragement and opportunity that he afforded to all earnest workers. The recipients of his aid can be numbered by hundreds, and many of them are to-day his worthy successors in various fields; and their places in turn will gradually be taken by a vast number of men and women who will perpetuate his memory by efficiently and reverently continuing his work.

This evidence of the donor's beneficence is a noble and impressive memorial of one who merited his country's profoundest gratitude; but the bust signifies something more, for it is a recognition of that zeal, fidelity, self-sacrifice, intelligence and strength in the American character so preeminently typified by Spencer Fullerton Baird.

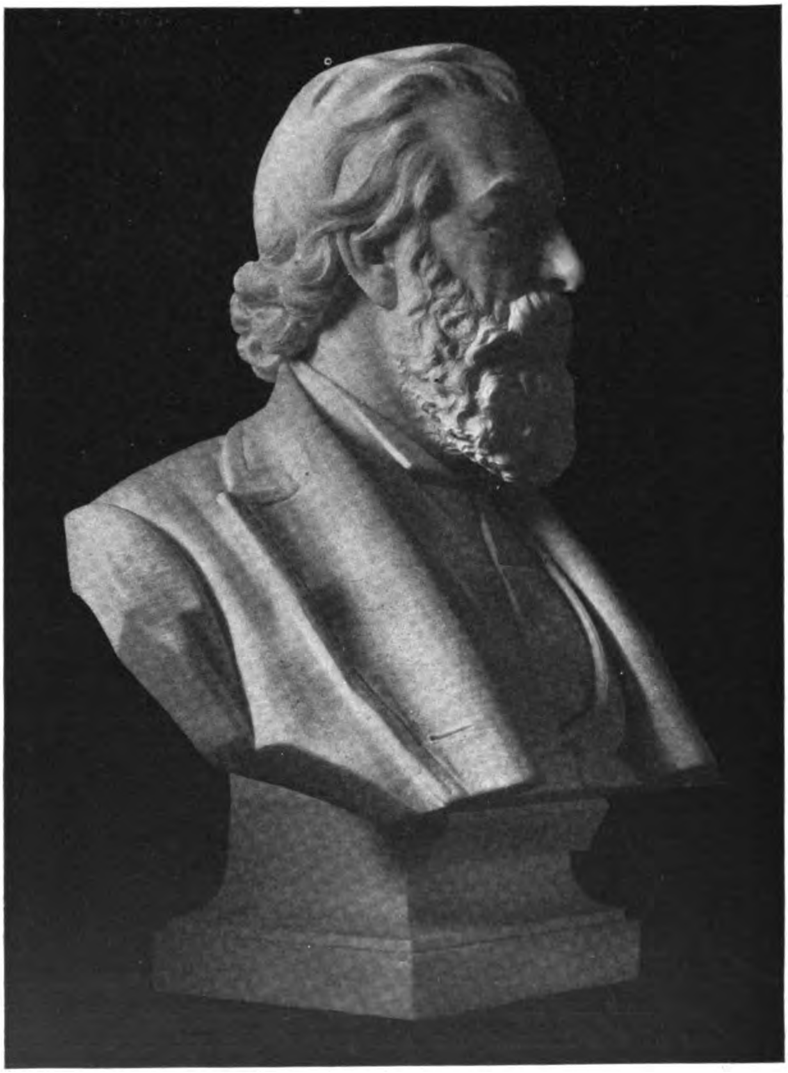
Joseph Leidy

By Professor WILLIAM KEITH BROOKS

JOHNS HOPKINS UNIVERSITY

Joseph Leidy was born in Philadelphia, there he passed his threc score years and ten, and there he died. For forty-five years he was an officer of the Philadelphia Academy of Natural Science, and a professor in the University of Pennsylvania for forty years. His character was simple and earnest, and he had such a modest opinion of his talents and of his work that the honors and rewards that began to come to him in his younger days, from learned societies in all parts of the world, and continued to come for the rest of his life were an unfailing surprise to him.

His knowledge of anatomy, and zoology, and botany, and min-



eralogy was extensive and accurate and at his ready command. Farmers and horticulturists came to him and learned how to check the ravages of destructive insects; physicians sent rare or new human parasites and were told their nature and habits and the best means of prevention; jewelers brought rare gems and learned their value. His comments, at the academy, on the recent additions to its collections, gave a most impressive illustration of his ready command of his vast store of natural knowledge.

Leidy wrote no books, in the popular meaning of the word. He undertook the solution of no fundamental problem of biology. There are few among his six hundred publications that would attract unscientific readers, or afford a paragraph for a newspaper. They are simple and lucid and to the point. Most of them are short, although he wrote several more exhaustive monographs. They cover a wide field, but most of them fall into a few groups. Many deal with the parasites of mammals—among them, one in which his discovery of Trichena in pork is recorded.

Two hundred and sixteen, or about a third of his publications, are on the extinct vertebrates of North America. His first paper on paleontology was published in 1846, and his last in 1888, as the subject occupied him for more than forty years. He laid, with the hand of master, the foundation for the paleontology of the reptiles and mammals of North America, and we know what a wonderful and instructive and world-renowned superstructure his successors have reared upon his foundation. It was this work that established his fame and brought him honors and rewards. They who hold it to be his best title to be enrolled among the pioneers of science in America are in the right in so far as the founder of a great department of knowledge is most deserving of commemoration; but I do not believe it was his most characteristic work.

I can mention but one of the results of his study of American fossils. He showed, in 1846, that this continent is the ancestral home of the horse, and he sketched, soon after, the outline of the story of its evolution which later workers have made so familiar.

More than half his papers are on a subject which seems to me to contain the lesson of his life. Like Gilbert White, he was a home-naturalist, devoted to the study of the natural objects that he found within walking-distance of his home, but he penetrated far deeper into the secrets of the living world about him than White did, finding new wonders in the simplest living being. In the intestine of the cockroach and in that of the white ant, he found wonderful forests of microscopic plants that were new to science, inhabited by minute animals of many new and strange forms. His beautifully illustrated memoir on *A Flora and Fauna within Living Animals* is one of the most remarkable works in the whole field of biological literature. Another memoir gives the results of his study of the anatomy of snails and slugs. The inhabitants of the streams and ponds in the vicinity of his home furnished an unfailing supply of material for research and discovery, and many of his publications are on aquatic animals. He finally became so much interested in the fresh-water rhizopods that he abandoned all other scientific work in order to devote all his attention to these animals. His results were published in the memoir on *The Fresh-water Rhizopods of North America.* This is the most widely known of his works. It is, and must long be, the standard and classic upon its subject. I have no time to dwell upon his work as the naturalist of the home—his best and most characteristic work. Its lesson to later generations of naturalists seems to me to be that one may be useful to his fellowmen, and enjoy the keen pleasure of discovery, and come to honor and distinction, without visiting strange countries in search of rarities, without biological stations and marine laboratories, without the latest technical methods, without grants of money, and, above all, without undertaking to solve the riddles of the universe or resolving biology into physics and chemistry.

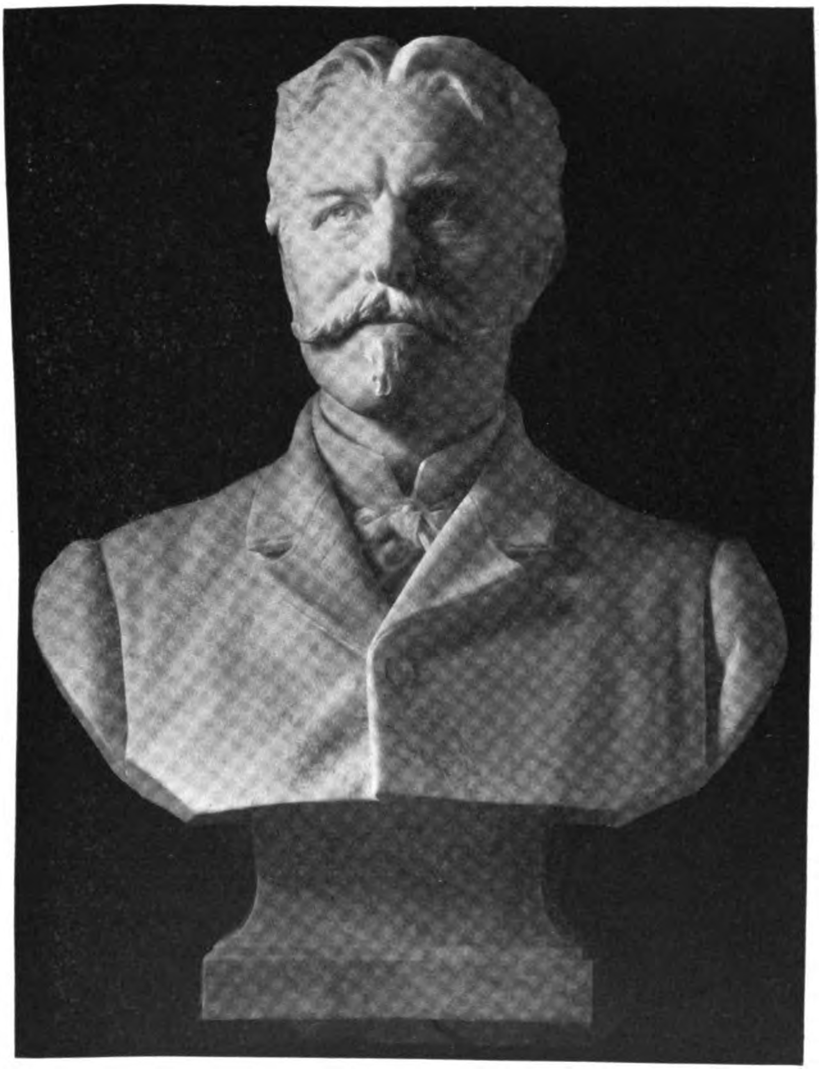
If one have the simple responsive mind of a child or of Leidy, he may, like Leidy, 'find tongues in trees, books in the running brooks, sermons in stones, and good in everything.'

Edward Drinker Cope

By Professor HENRY FAIRFIELD OSBORN
COLUMBIA UNIVERSITY AND THE AMERICAN MUSEUM OF NATURAL HISTORY

In the beautiful marble portrait of Edward Drinker Cope, modeled by Mr. Couper and presented by President Jesup, you see the man of large brain, of keen eye, and of strong resolve, the ideal combination for a life of science, the man who scorns obstacles, who while battling with the present looks above and beyond. The portrait stands in its niche as a tribute to a great leader and founder of American paleontology, as an inspiration to young Americans. In unison with the other portraits its forcible words are: 'Go thou and do likewise.'

Cope, a Philadelphian, born July 28, 1840, passed away at the early age of fifty-seven. Favored by heredity, through distinguished ancestry of Pennsylvania quakers, who bequeathed intellectual keenness and a constructive spirit. As a boy of eight entering a life of travel and observation, and with rare precocity giving promise of the finest qualities of his manhood. Of incessant activity of mind and



body, tireless as an explorer, early discovering for himself that the greatest pleasure and stimulus of life is to penetrate the unknown in nature. In personal character fearless, independent, venturesome, militant, far less of a quaker in disposition than his Teutonic fellow citizen Leidy. Of enormous productiveness as an editor, conducting the *American Naturalist* for nineteen years, as a writer leaving a shelf-ful of twenty octavo and three great quarto volumes of original research. A man of fortitude, bearing material reverses with good cheer, because he lived in the world of ideas and to the very last moment of his life drew constant refreshment from the mysterious regions of the unexplored.

In every one of the five great lines of research into which he ventured, he reached the mountain peaks where exploration and discovery, guided by imagination and happy inspiration, gave his work a leadership. His studies among fishes alone would give him a chief rank among zoologists, yet among amphibians and reptiles there never has been a naturalist who has published so many papers as Professor Cope, while from 1868 until 1897, the year of his death, he was a tireless student and explorer of the mammals, living and extinct. Among animals of all these classes his generalizations marked new epochs. While far from infallible, his ideas acted as fertilizers on the minds of other men. As a paleontologist, enjoying with Leidy and Marsh that Arcadian period when all the wonders of our great west were new, from his elevation of knowledge which enabled him to survey the whole field, with keen eye he swooped down like an eagle upon the most important point.

In breadth, depth and range we see in Cope the very antithesis of the modern specialist, the last exponent of the race of the Buffon, Cuvier, Owen and Huxley type. Of ability, memory and courage sufficient to grasp the whole field of natural history. As comparative anatomist he ranks with Cuvier and Owen; as paleontologist with Owen, Marsh and Leidy—the other two founders of American paleontology; as natural philosopher less logical but more constructive than Huxley. America will produce men of as great, perhaps greater, genius, but Cope represents a type which is now extinct and never will be seen again.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DE LAND

PITTSBURGH, PA

VIII. Subscribers' Pioneer Telephone Equipment

IN the previous chapter it was shown how the primitive telephone set supplied to subscribers by the New Haven and other pioneer exchanges consisted only of a mahogany or rubber magneto hand telephone hung on a steel hook screwed into wall or board, and how the use of the circuit-breaking push button was the approved method of calling central. No vibrating bell was supplied to the subscriber. When central called, attention was attracted with the aid of a buzzing, squealing noise, that was sent through the telephone by manually and rapidly operating a large induction coil attached to the switchboard. That was the method in vogue early in 1878, and, as already stated, in the beginning it was the custom to use this one-hand telephone as

Fig. 22.

transmitter and receiver, dexterously moving it from lips to ear and from ear to lips, as the conversation progressed. From time to time instructions were issued to subscribers on the proper use of the telephone. One of the first read: 'Do not talk with your ear, or listen with your mouth.' Where a subscriber was willing to pay for 'two telephones,' he enjoyed the unusual convenience of following the now common method of holding the receiver to his ear while talking into the transmitter, as shown in Fig. 22. Not many duplicate telephones were installed, but occasionally an editor would consider his time of sufficient value to justify the increased outlay of $10 a year for a 'second telephone.'

Following the now famous experiments with his telephones at the Centennial, Alexander Graham Bell had displaced the parchment or membrane diaphragm with one of iron, and brought out the wooden hand telephone to take the place of the oblong box, so inconvenient for general use. Then, in December, 1877, a few long rubber-encased hand telephones similar in form to the present receiver were sent out to several exchanges as an experiment. On July 1, 1878, Mr. Coy had 230 mahogany hand telephones, about 100 rubber hand telephones

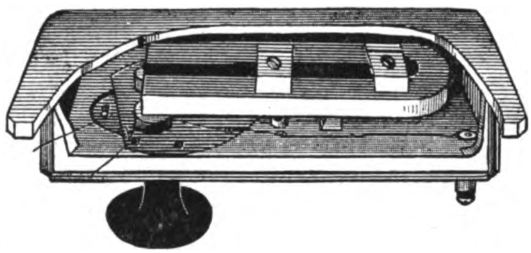


Fig. 23.

and a dozen box telephones. But this rubber hand telephone did not go into general use until the summer of 1878, and, in some exchanges, never really supplanted the original wooden hand telephone, the earlier magneto sets doing so.

Meanwhile an improved form of the oblong box telephone, shown in a previous chapter, was brought out in June, 1877, but met with no favor, as it also required a table or a shelf for its support in a horizontal position. In August, 1877, came the first of the oblong box telephones remodeled so as to be fastened to the wall in a vertical position (Fig. 23). The only telephone circuits in those days were private and social lines, the first commercial exchange opening in January, 1878, and users of projected private lines did not take kindly to this innovation, preferring to have the more convenient hand telephone which could so easily be shifted from lips to ear. And this was the prevailing sentiment even after exchanges were in operation. Thus this upright form of box telephone did not come into general use until the winter of 1878–79, when it served only as part of a subscriber's set.

In the autumn of 1878, the parent Bell company brought out the first of the many forms of magneto bell telephone sets. This early type of wall set (Fig. 24) had the rubber-encased hand telephone hung from a hook projecting through the door on the front of the box. The attaching of two hand telephones to the magneto to serve as transmitter and receiver (Fig. 25) naturally followed. The introduction of this magneto ringing device displaced the circuit-breaking push-button method of calling central, and the single-stroke bell as part of the subscriber's equipment. It also enabled the local com-

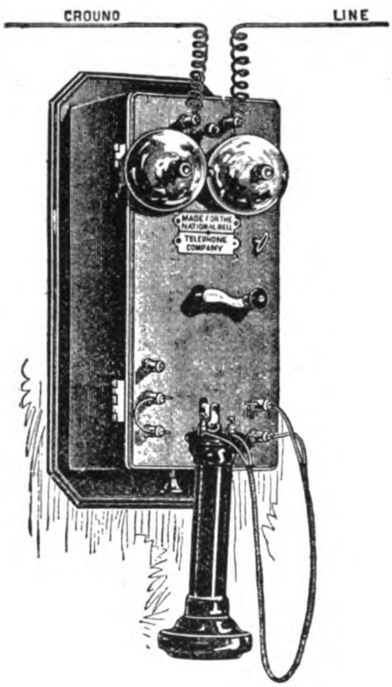


FIG. 24.

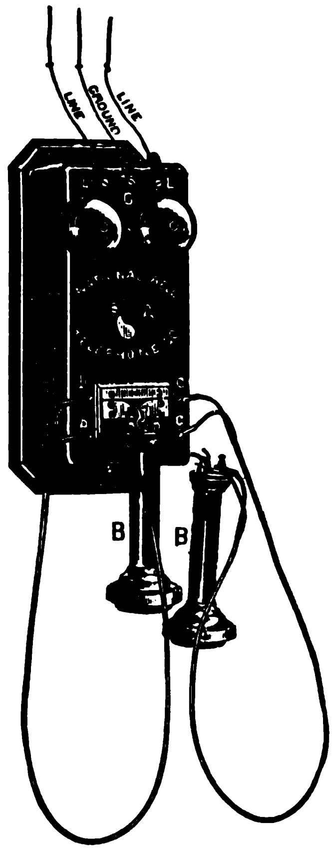


FIG. 25.

panies to secure more equitable rates by increasing the rental where the new equipment was installed.

In the pioneer days when local rates ranged from $18 to $36 per year, nearly all the subscribers were on party-lines, and few lines carried less than twelve telephones. 'How many boxes are there on your line?' was a question often asked by subscribers in the days when it was not unusual to have twelve, or even twenty or more subscribers on a grounded iron-wire circuit in towns. In May, 1878, it was stated that one circuit had 'fifty-six instruments, and conversation is carried on with perfect ease.' Another town boasted of forty-three telephones on one line. Naturally there was more or less eavesdropping, with the usual entailed bitterness. Thus the parent company found it advisable to sanction the addition of a secrecy-switch to the magneto bells supplied by the different manufacturers. One form of this lock-out switch is shown on the front of the magneto box in Fig. 25. Removing the receiver or hand telephone from the box caused the latter to fly up, just as the hook on the side of the modern telephone does. If the subscriber desired to converse with some one on the line to the right of his telephone, he would turn the switch to the right, thus shutting out all subscribers to the left, but still leaving it possible for eavesdroppers on the right to listen in. If the switch was turned to the left, the subscribers to the right were cut out. To operate the bell it was only necessary to turn the crank at a moderate speed and at the same time to press the button underneath the box the number of times that corresponded with the number of rings required to call the given station.

The next change came in the adoption of the first of the vertical boxes as a transmitter in connection with the magneto-call bell, and the use of the hand telephone as a receiver. In method of operation both instruments were identical, either could be used as transmitter or receiver, and both were fastened to the wall side by side (Fig. 26). The approved method of calling then in vogue is also shown (Fig. 27). The circular of instructions sent out with this early wall set read:

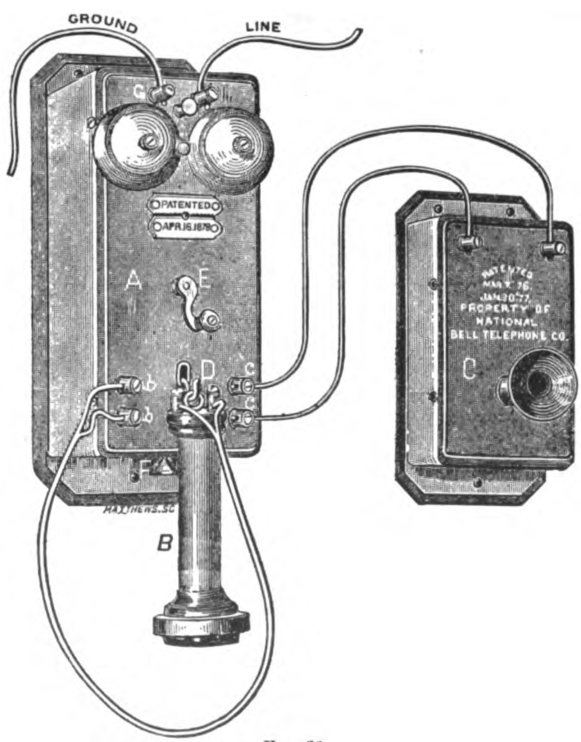


FIG. 26.

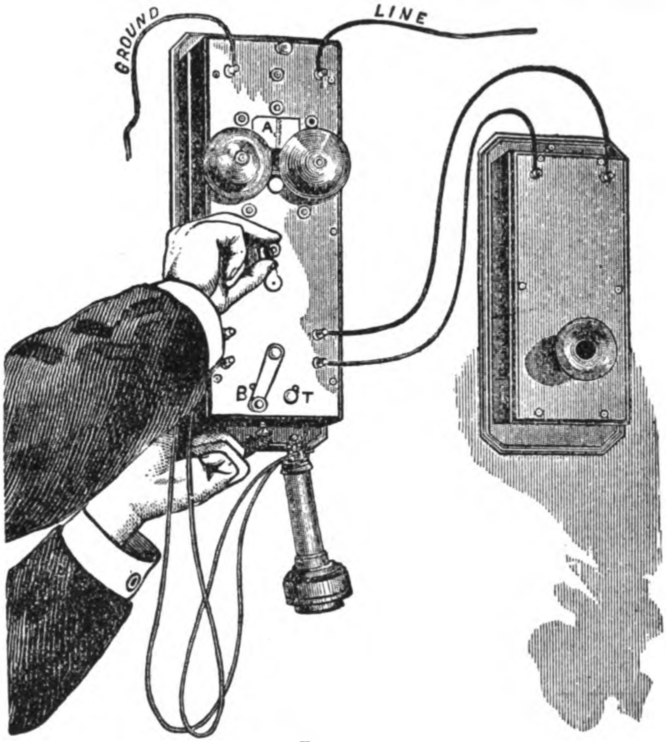


FIG. 27.

A person is shown (Fig. 28) talking to a box telephone, keeping a hand telephone pressed against his ear. It is evident that he can talk or listen without removing either instrument, and consequently can carry on a conversation with as much ease and rapidity as if in the presence of the other person. If he is in a noisy place he can, in listening, turn his other ear to the box telephone, thereby hearing what is said with increased loudness, and at the same time shutting out external sounds. All the telephones described above do not require any battery whatever, and for ordinary purposes are all that can be desired, both for loudness and distinctness.

By reason of its simplicity of operation, the 'push-button magneto' (Fig. 29) type of instrument was popular during its brief existence. In construction and operation it materially differed from the crank instrument. In the latter, the current followed the revolving of an armature within a magnetic field; in the former, the current was produced by pushing the button on the face of the instrument, thus 'forcibly detaching a soft iron armature from the poles of a permanent magnet surrounded with coils of insulated wire.' The following instructions were sent with this instrument in 1880:

To signal the central office, press the black knob *firmly* twice, turn the switch so as to cut out the stations on the same line beyond, then place the telephone to the ear. If there are two black knobs on the instrument, one above

the other, press the upper one steadily while pushing the lower one. If the line is not being used, your bell will ring every time you press the lower knob. If the line is in use, your bell will not ring. As soon as you hear the operator, give him your name and the name of the person to whom you wish to speak; then replace the telephone on the hook. When the person called for is connected with your wire, your bell will ring. Be sure, on removing the telephone again, to turn the hook switch as before, unless notified by the central office to turn in an opposite direction. When you are notified by the central office that a person wishes to speak to you, keep the telephone at your ear, as the person will be ready to speak as soon as you are notified.

Owing to the rapidity with which improvements and modifications in equipment appeared during the first five years, rarely did the subscribers in any two exchanges have the same type of instruments, the newer exchanges having the later types except where the most rigid economy was practised. Yet it often happened that when the patrons in one town learned that the subscribers in an adjoining town had a later type of instruments, the local owners were given no rest until up-to-date instruments were installed, even though the equipment declared to be antiquated and obsolete had been in use only from twelve to eighteen months.

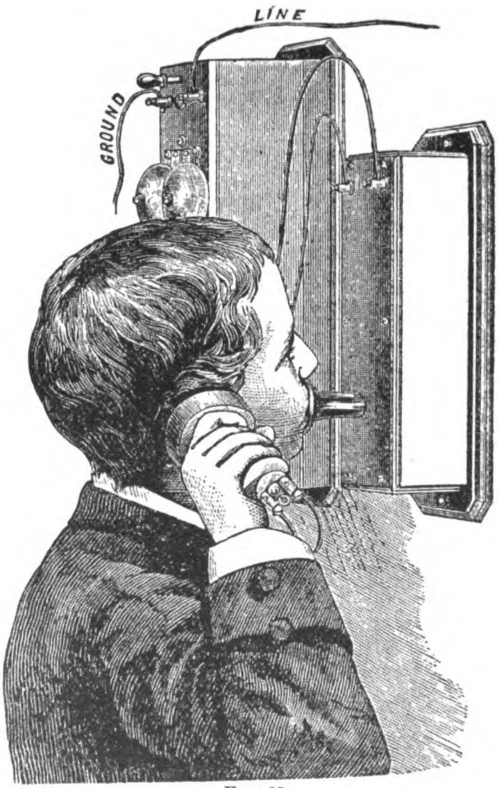


FIG. 28.

Of course, the parent company, through its earnest efforts to afford the operating companies every serviceable improvement, was indirectly responsible for this unavoidable variance in subscriber-equipment. And while modifications in form and improvement in workmanship were not patentable, they were the result of careful and costly experiments in the course of which the parent company was 'obliged to withdraw from use and condemn many thousands of instruments, not because they were inoperative, but because others were better.' Transmitters and receivers were kept in good condition by the parent company, and replaced with new or improved types as often as necessary without expense to the local company. But the remainder of the equipment had to be purchased from such manufacturers as were able to supply it. Hence, to displace old with new equipment was often a costly change for the local company.

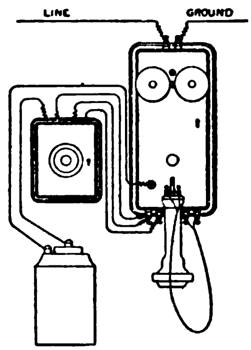


FIG. 29.

In commenting on the trouble caused by defective telephone cords, the Committee on Telephone Supplies reported at the fourth convention (1882) that

while the telephone business has been one marked with progress, we have to confess that in this respect we have progressed but slowly, if at all. We have had cords of all styles, of all sizes, and constructed of all metallic material from the 'Gold Foil' to the 'Steel Spiral'; from the large and unwieldy to the small and ductile. We have had 'tips' with shields, 'tips' with spirals, and 'tips' without name. We have had forms of eyelets through which the cord is threaded and wrapped with linen. We have had variegated colors from the serpentine braid to the pale blue and the 'polka dot.' We have had all forms but the good. . . . A cord is wanted that will not ravel at the ends, thus causing 'cut-outs' in subscribers' conversations. A greater degree of perfection is required in fastening the tips. They should be light in weight and free from kinks or twists.

In 1883, Mr. C. N. Fay said:

The first magneto bells we had (in Chicago) came from Boston and were manufactured by Williams, four years ago, and they were certainly the best, so far as lasting qualities were concerned. The next bells we bought, in the fall of 1879, were the first bells Gilliland made. Bells that come in under two years are not worn out, but there is some defect which requires repairing, and then the bell can be put back in service. . . . Their life will not be over four years. If they are not worn out, the dust and the battering they get and the general abuse they receive from subscribers makes them practically worthless after a time, and the subscriber says: 'I won't have that thing on my wall.' We have got to count upon replacing our entire stock of magneto bells about once in every four years.

In one way it was encouraging to the owners of the pioneer local plants to perceive how rapidly the list of subscribers increased. In another way this unexpectedly rapid growth was depressing in character, because it had not been anticipated and consequently the plant had not been constructed on corresponding lines. Where the investment was not of a speculative nature, but made on a permanent basis, the owners soon realized that they had not been just to themselves nor to the public in building so cheaply and so sparingly. Again, the funds necessary to meet these constantly changing conditions were not readily forthcoming, for not one in ten of the pioneer organizations earned dividends prior to 1882.

In 1880, the parent Bell company gave this sensible advice to its operating companies:

> Don't expect people to 'study up' the instruments themselves, but have them explained politely and patiently. Some large exchanges publish a monthly pamphlet containing corrected lists of subscribers, new information, etc., and defray the whole or part of the expense of its publication by accepting advertisements for alternate pages. A pamphlet issued in this way costs little or nothing, and its monthly coming is appreciated by subscribers. Don't forget that the local papers are a valuable means of popularizing your business. Advertise in them as much as circumstances demand and warrant.

The parent company also stated that printed lists of subscribers should be prepared in 'form like a dancing programme.' Incidentally it may be added that current subscribers' directories in cities like Pittsburgh now weigh about three pounds each, while the directory used in New York City weighs nearly twice as much. The latter contains the names of more than three hundred thousand individuals or firms and about four hundred thousand copies of each issue are distributed. Owing to the frequent revision of Bell subscriber-lists these 'dancing-programmes' are admittedly the most reliable directories in the cities.

Although Graham Bell's hand telephone transmitted messages with remarkable clearness, even over long distances where no disturbing causes interfered, yet it did not possess sufficient power to satisfactorily serve under the varied conditions that developed as the scope of telephone service expanded in all directions. Even though there were no electric-light circuits and no trolley lines, the inductive effect and the zone of noise was always in evidence; for telegraph lines paralleled many telephone circuits and, as practically all lines were grounded, the effect of earth currents was often plainly perceptible. So sensitive was the telephone found to be, that scientists employed it in delicate researches to detect the flow of electrical currents so minute as to be inappreciable to all other instruments. And Graham Bell stated that in standing on a large board placed on his lawn, if a single spear of grass came in contact with his foot while experimenting with his telephone, the effect of ground currents was instantly perceptible, yet disappeared the moment the connection was broken between shoe and grass.

THE GENERAL ECONOMIC IMPORTANCE OF MOSQUITOES[1]

BY PROFESSOR JOHN B. SMITH
RUTGERS COLLEGE, NEW BRUNSWICK

NO one should be better qualified than a Jerseyman to speak on this subject, for no state in the union has suffered more in reputation and in arrested prosperity from mosquitoes than New Jersey.

During the four or five years last past, I have had opportunity to observe conditions closely, and there is not a section whose development has not been in some way affected by this insect pest.

First: by the carriage of malarial disease, and by the term carriage, I mean, of course, not the direct transmission from one individual to another, but that service as intermediate host in the development of the parasitic organisms that cause the disease.

Anopheles occurs throughout our state, although the *A. maculipennis,* which is the only one of our species known to be affected by the parasite, is comparatively rare and is, curiously enough, more abundant in the more northern, hilly portions than in the southern lowlands, where breeding places are more numerous.

Malarial diseases are much less common with us than they were a few years past, and that is due partially to the improvement of sanitary conditions which lessens mosquito breeding in densely populated districts, and partly to the much more thorough treatment which a patient now receives from the attending physician.

It requires the presence of a patient infested with the plasmodium, as well as of the proper species of *Anopheles,* to start an epidemic of malaria, but the mosquitoes need not be at all common to make trouble. I have in mind an instance very much in point: A village of high-class residences, well-located, generally healthy and where mosquitoes were accounted among the rarities; but, as it happened, the few that did occur were *A. maculipennis.* Into that community, where no case of malaria had ever been known, was introduced a gang of Italian laborers, recent immigrants, it was later found, and most of whom had been affected with the fever in Italy.

Before the end of the season a considerable number of cases of the æstivo-autumnal variety had developed in the village and some of them of the most severe type. This led to a search for the cause, and the breeding places for the few mosquitoes that occurred were located and abolished. Italian laborers have been tabooed in that locality since then, and for the two years last past no further case has developed, so far as I have been able to find.

The agency of mosquitoes in the transmission of other febrile diseases is so definitely established that their economic importance as a menace to public health can not be doubted. Their agency in a number of other diseases is suspected with good reason. In New Jersey a recent amendment to the general health law classifies 'waters in which mosquito larvæ breed' among the nuisances over which local boards of health have summary jurisdiction, and we have the fullest powers under our law for dealing with the mosquito pest. Action under those powers is not yet the rule, but each year sees a greater advance in this direction.

The great bulk of the mosquitoes occurring in this section of our country are not agents for the transmission of any disease known to us; but their attacks may be, and often are, so annoying as to form a positive injury to the health of weak or sickly individuals by robbing them of sleep and by the constant irritation of their bites. To some persons the bite of a mosquito is really a serious matter and severe swelling and inflammatory conditions are caused. To nobody is it a pleasure to be bitten, and there is no point of view from which the insect is not a detriment to health and the pursuit of happiness.

Second: the influence on the agricultural development of an infested area. This is a point that is rarely referred to, and it is not realized that the character of a farming district may be substantially modified by mosquitoes. Dairying, or supplying milk for the markets of New York, Philadelphia and our own cities, is a very important industry in New Jersey, and a large portion of the Philadelphia supply comes from the southern part of that state. We have a stretch of land in one of these southern counties eminently adapted for dairying, and where herds have been in times past established again and again; but they never lasted long, simply because the incessant attacks by swarms of mosquitoes reduce the yield as well as the quality of milk to such an extent as to make the animals unprofitable. It has been necessary to change the type of agriculture in these areas to a less profitable one simply because of the mosquito pest.

Another section of our state, not far from the shore, is peculiarly adapted to the growing of small fruits, particularly berries of various kinds. These are very profitable and find a ready sale in the near-by resorts. But just about the time when these berries ripen, the country is apt to be flooded with swarms of mosquitoes from the salt marshes, and when they do come it is impossible to get pickers. Gangs of Italians have been brought down from Philadelphia, they have started in

[1] Read at a meeting of the American Society of Tropical Medicine, Philadelphia, December 7, 1906, and published under its imprimatur.

blithely, and by noon have given up the work and started back to the city. Of course such conditions do not occur every year; nor do they continue throughout the season; but they do occur often enough and last long enough to make the farmer hesitate about putting in a crop which he knows would pay if he got it, but which he may be compelled to see rot on the ground because no pickers can be found to brave the mosquito hosts. Few persons are ready to believe at a first statement how important a factor in the agricultural development of a region the mosquito may become.

Third: there is the effect of the mosquito upon the availability of a territory for development as a residential district.

This is the most important feature of the problem in New Jersey to-day, and there is no exaggeration in the statement that the elimination of the mosquito would add ten millions to the taxable value of real estate in two years. Let me illustrate: New York City is a highly desirable place of residence in winter; but less so in summer, and there are thousands of residents of New York City who are well able to afford a summer home within an hour or two from town, and who are quite willing to pay for it. New Jersey has many places ideal in situation and accessibility, and one such place developed rapidly to a certain point and there it stood, halted by the mosquitoes that bred in the surrounding marsh lands. Country club, golf, tennis and other attractions ceased to attract when attention was necessarily focussed on the biting or singing pests that intruded everywhere, and the tendency was to sell out. But the owners were not ready to quit without a fight, and an improvement society was formed which consulted with my office and followed my advice. In one year the bulk of the breeding area was drained, mosquitoes have since been absent almost entirely; one gentleman, not a large owner, either, told me his property had increased $50,000 in value, and new settlers began to come in. This year one of the worst breeding areas of the olden day was used as a camping ground, and 100 new residences are planned for next year.

New Jersey has miles of sea coast that is unequaled for summer resorts. All but a few points are practically abandoned as uninhabitable. Barnegat Bay and its surroundings constitute a fisherman's paradise, and again and again settlements have started, done well for a season and have been abandoned. Those who came one year never came again, and many who came for a month stayed only a day.

The only thing that prevents a continuous line of summer resorts along the entire shore line is the mosquito pest, and were that removed there would be a scramble to get land.

We may take the result on Staten Island as an example. This Island, now a part of Greater New York, is geographically a portion of New Jersey, separated from the mainland by a narrow stream or 'kill,' on both sides of which salt marsh flats extend for a mile or more to the highland. The southern and eastern shore is a continuation of the New Jersey coast line from the mouth of the Raritan River, and like it has a number of indentations more or less bordered by salt marsh areas. On all these marshes mosquitoes bred in uncounted millions and spread throughout the island. Result: several square miles of most desirable territory for suburban residences entirely unsettled. There are two shore resorts, South Beach and Midland Beach, feeble imitations of Coney Island in some directions, but more desirable in others, that just maintained themselves despite their attractions. During the day conditions were tolerable along shore, but as soon as the sun was low in the horizon trouble began, and as it became dusk the fight began, and pleasure seekers sought shelter behind screens or started for home.

This past summer, under the supervision of Dr. A. H. Doty, state quarantine officer, the salt marshes have been drained in the manner advocated by me, and the beginning was made on the eastern and southern shores, where Midland and South Beach are situated. I need hardly say that very few believed in good results, and scepticism was general even in circles where we might have expected material support But we got the needed money, secured a contractor within our estimate, and the eastern and southern shore work was done before the breeding season set in.

Result: there have been very few mosquitoes of any kind, and practically no marsh mosquitoes along this shore during the entire season. Visitors stayed longer and came more frequently to both beaches, which enjoyed a season of unparalleled prosperity, taxing the full capacity of the transportation companies. As the season advanced, the drainage work extended farther and farther away from the populated sections, permanent residents began to notice that nobody was putting in screens, and that screened porches were never used. On the golf links games could be carried on while the light lasted, and outdoor dinners and suppers became the rule at the Country Club. When it was fully realized that there was practically no mosquito pest, and the improvement in the character of the drained territory was obvious, there was a change in public sentiment. Plans were made for extending the attractions at the beaches, and many thousands will be put into new amusement enterprises during the present winter. Land values stiffened and very little was offered for sale.

Two industrial enterprises decided to locate on the marsh area on the west of the island, and these are expected to employ, respectively, 4,000, and 6,000 men, most of whom will undoubtedly settle near-by. These enterprises will result in actually reclaiming a large section of the marsh, which is something that mosquito drainage does not and was not intended to accomplish.

It is fair, therefore, to consider the mosquitoes of great economic importance, and as serious drawbacks to any community from three points of view:

First, their influence, direct and indirect, upon the health and well-being of the inhabitants.

Second, their influence upon the development of the agricultural resources, preventing or limiting the profitable use of infested territory for certain purposes.

Third, their influence upon land values due to the drawbacks mentioned under 1 and 2.

Having determined these points, it remains to determine whether, in any stage, any species of mosquito is of any value to man, directly or indirectly. The adult is a feeder upon juices of plants and animals; it produces nothing of use to us and removes nothing that is detrimental. It is of absolute importance to the continued existence of those microzoa that pass one stage of their existence in the mosquito body and nowhere else; but no one will argue that it is desirable to continue these organisms, and if the destruction of the mosquito is accompanied by the elimination of Plasmodia, Trypanosomes, Filaria and others of similar ills, a double good will have been accomplished.

In the larval stages the species are feeders upon the microorganisms, animal and vegetable, that occur in more or less stagnant waters. In a way they are scavengers, and it can not be definitely said that they may not destroy or limit some organisms that might otherwise be or become harmful to man. Could it be proved then that these stagnant water areas are necessary, it might be a question whether it is wise to war on mosquitoes until we have a more definite knowledge of the food of the wrigglers. But are these stagnant waters of any use to man, and is it necessary to retain them? On this point also it seems to me the answer must be against the insects, leaving absolutely no evidence that they are of any use or benefit whatever to the human race, directly or indirectly, as larva or adult.

The legislature and governor of New Jersey are sufficiently convinced of the injurious effects of the mosquito upon the development of the state to venture an investment of $350,000 in the effort to secure the practical elimination of the pest.

HOW SHALL THE DESTRUCTIVE TENDENCIES OF MODERN LIFE BE MET AND OVERCOME?

BY RICHARD COLE NEWTON, M.D.

WHEN Bichat referred to civilization as 'nothing more than the environment which tends to destroy humankind,' he had in mind, presumably, the so-called civilization of his own time, which we are willing to concede was considerably below that of to-day in every respect and far below that of the Greeks and Romans. To illustrate the superior efficiency of what we may call a natural method of treating diseases over the highly artificial and fanciful methods which prevailed long after Bichat's time, an extract from Higgins's 'Humaniculture' may be paraphrased as follows: It is a matter of record that Augustus Cæsar recovered his health after the expedition into Spain, when suffering from an attack of illness, said to have been due to an inflammation of the liver, by a treatment of baths and an exclusively vegetable diet; whereas, Louis XIV. of France, living 1,600 years later, "in the short space of one year took 215 different medicines, 212 enemata and was bled no less than 47 times." Here is a striking example of progression backwards. As Dr. Higgins sententiously remarks, "A kindly historian would surely take such adverse circumstances into consideratión when he gave his judicial opinion on the acts of such unfortunate monarchs."

There are still those who seem to believe that every disease has its appropriate and efficient remedy: a dogma long ago exploded. The only certain remedy for any disease is a man's own vital power. If the body is strong enough and well-nourished enough it will throw off the diseased condition. Drugs, outward applications, mental or spiritual influences, baths, regulation of the diet, ventilation and temperature may be of such efficient and timely aid as to turn the tide of battle from defeat to victory and may help nature to triumph. They, however, are only adjuncts. The natural inherent power of the body itself is the *sine qua non,* the absolute essential; without which all therapeutic measures whatever will prove unavailing.

Admitting then that this condition of bodily vigor is necessary before we can recover from sickness, or can withstand a severe injury, or shock, is it not possible to so train and develop the body that it will be practically non-susceptible to illness and not only that, but so that it will be far more efficient and enduring for all of life's work than the non-trained or improperly developed body? There can be only one answer to this question.

Probably the day has gone by when it is necessary to argue with intelligent people in regard to the relationship between a man's intellectual power and his bodily health and development. Had we not the splendid example of the Greek civilization before us, we could still reason it out from analogy and observation that a healthy mind can not under average conditions exist outside of a healthy body. As President Eliot has neatly put it, "The scholar must use strenuously a tough and alert body and possess a large vitality and a sober courage."

The contempt in which bodily exercise has been held for many centuries and the undue laudation of mental as opposed to physical prowess are to a great extent at least a residuum of the reaction of the ecclesiastical and medical superstitions of the dark ages against the natural methods of the Greek philosophers and against what was considered a too predominant admiration for the physical as opposed to the spiritual side of life. It seems to have been considered heathenish to be well formed and well developed, erect of body and broad of chest. The ideal saint was anæmic to a degree; the ideal successful lawyer or prosperous merchant was of 'full round belly with good capon lined'; the ideal lady was Miss Lydia Languish with wasp-like waist and no organs in particular. For the last half century, however, the reaction toward universal physical prowess and bodily excellence has been advancing, and just now with its gradually accelerated momentum it is making wonderful progress. A great and widespread awakening is taking place in regard to the proposition which I have laid down as axiomatic: that there must be a synchronous and properly balanced development of mind and body, if man is to even approximate his glorious destiny.

Unfortunately, many of the simplest rules relating to the development and care of the human body are as yet enveloped in mystery, or, to speak more exactly, no two authorities seem to agree upon them. The investigation of the régime in vogue in a number of sanatoria by Professor Fisher has demonstrated that scarcely any two of them agree in the diet prescribed for consumptive patients. The calorific value of the prescribed food for each person ranges, in the different institutions, between 2,000 and 5,500 calories per diem, or a difference of 250 per cent. If then in a disease which has received the great amount of attention and study which has been bestowed upon tuberculosis, for a number of years, and in which the modern treatment is mainly confined to the three natural agencies of diet, fresh air and sunlight, there is no accord amongst clinicians as to the standard diet, what wonder is it that in other diseased conditions and more especially in health the greatest confusion prevails in regard to the best form of diet?

Chemical and microscopic experiments in laboratories, however important, even absolutely essential though they are, will never decide certain vital questions. Note the fantastical deduction of Metchnikoff, who asserts that the large intestine is really a *lusus naturæ,* a dangerous and disease-breeding portion of the economy which had better be dispensed with, at least to the extent of a few feet. The idea does not seem to have dawned upon him that the colon might not be dangerous were it not overloaded with the unused products of an excessive alimentation. Nor can experiments upon animals, nor investigations in the professor's laboratory, ever determine this question, while there are already enough isolated instances on record to render it at least extremely probable that an extended investigation of a sufficient number of human beings would prove that the dangerous element in the life of the modern man is not the anatomical mistake of superabundant intestine, but the overindulgence of a pampered appetite. Nor can *a priori* reasoning be depended upon to settle some very simple controversies, as, for instance, that between the vegetarians and the flesh eaters. So far as the writer knows, no reliable statistics have ever been compiled in regard to the longevity and efficiency of either of these classes as compared with the other. The means for settling this important question lie ready to our hands, viz., a careful collection and analysis of the statistics.

The question of the harmfulness or the innocuousness of tobacco is so far from settlement that certain good authorities declare that its use may be a cause of arterio-sclerosis, while others say that, used in moderation, it is harmless. There is every probability that a properly conducted questionaire would settle this moot point, and so we might undoubtedly settle the question of the real influence of coffee and tea upon the health, and of various articles of diet, as well as meat and fish. Jonathan Hutchinson's contention that fish eating is the cause of leprosy and the commonly accepted belief that beri beri is due to eating musty rice, or even rice in good condition in undue proportion, have an exceedingly important bearing upon the question question of dietetics.

The United States can no longer afford to neglect the experimental study of tropical diseases, since we are building the Panama Canal and have vast tropical possessions in the Philippines, not to mention Porto Rico. There is every encouragement to prosecute such researches when we reflect upon the splendid achievements of our army surgeons, Reed, Gorgas, Ashford, Sternberg and others. Life has been rendered happier and more secure by the devoted scientific labors of these men. Col. Giles has said, speaking of tropical diseases, in regard to the adaptability of the English to life in India, that Clive, being a genius, "naturally possessed the originality to modify his habits to his new surroundings and so survived to become an empire-builder and a hero. Nor was the case exceptional, for looking back on the history of our great Indian dependency, one can not fail to be struck with the high average ability of the few who survived to attain leading positions. . . . But the rank and file, who could not or would not learn, died off like rotten sheep." So it is to-day in all parts of the globe and nowhere more plainly true than in the United States that only an exceptional man, almost a genius, learns to modify his habits and his life to his environment and to triumph over his surroundings, his appetites and the absurd dictates of fashion. All the world over the genius carves out his proper régime for himself, the average man, ignorantly complaisant, indulges his appetites like the rest of his kind, dies like a rotten sheep and leaves his life-work unfinished.

The foregoing remarks have been confined mainly to diet because that is now the most pressing question before the people of this country and because, as said above, it is a matter upon which the utmost diversity of opinion exists. An observation of 10,000 people for ten years may be necessary to settle the question of the average standard diet for the average man at the different stages of life. If, however, it should take ten times as long and cost an amount equal to the national debt, it would be money and time well expended if the question should be settled thereby. In collating vital statistics, while the time of the death of any one man can not with certainty be predicted, the deaths of ten thousand individuals can be fixed with the nicest accuracy. Nothing can be asserted in regard to the individual, but in regard to the multitude the success of the statistical method is surprising. So in the matter of the health records of one man little can be assumed from a study of his habits; if, however, we could ascertain the life habits of 10,000 men, there is no question but that we could establish certain important truths in regard to them beyond all controversy. And it is equally certain that this is the only method by which some of these truths can be established. There is to-day absolutely nothing known about the etiology of cancer. This dreadful and constantly increasing disease has been studied in every way; in the individual, at the bedside, in the laboratory, in the post-mortem room, by inoculation into animals, etc., etc., and nothing conclusive has been discovered in regard to its causation. Had the life-habits of 10,000 people suffering with cancer been studied as to their diet, their occupation and surroundings, their use of alcohol, tobacco, etc., as well as the questions of heredity, of physical development and of the precedence of other diseased conditions in the same subject, there can be no doubt that important and probably convincing light, would have been shed upon the whole question. Studied in individuals, the cause of this scourge of the race has escaped every effort to locate it; had it been studied collectively, with a large enough number of observations, its cause would probably have been discovered and its ravages arrested. This probability becomes a certainty if the disease, as has often been asserted, is caused by diet or by residence in certain localities.

Lacking an authoritative standard of such an apparently simple thing as the human diet leaves the people a prey to any glib-tongued person who has any strictly original views to advance or pet theories to advocate. A certain magazine article which recently ridiculed most modern theories of diet and laid special stress on pork and beans as the ideal dietary of the vigorous and progressive, is a fair sample of the mischievous and pseudo-scientific writing which catches the popular eye and may do untold harm. The people deserve and should have a dietary standard, and there should be some competent and properly-equipped body, like the council on pharmacy and chemistry of the American Medical Association, who will spend the necessary time and trouble to settle the questions, not alone of the physiological diet, but of the proper bodily exercise, of ventilation, heating, bathing, etc., etc., in short of personal hygiene; as well as the problems affecting the public health, the pollution of streams and the extinction of tuberculosis.

Furthermore, any new system of therapeutics or any alleged new remedy should be submitted to this body of experts for trial, and approval or condemnation, before it should be possible to advertise it to the public. A variety of methods of treatment are from time to time exploited and no one has the legal right to supervise them or to decide whether, on the one hand, they can do what they are advertised to be able to accomplish or, on the other hand, whether they can be trusted not to harm and injure the people.

If the government can inspect food, it certainly has a right, and should exercise it, to determine, for example, whether or not any newly-advertised method of treatment is safe and appropriate. The objection may be raised against such a proposition as the foregoing that it would be an interference with the personal liberty of which our country is so justly proud; to which the obvious reply is that it is not suggested that any one who wishes to submit to any special course of treatment for a particular disease should be prevented by law from doing so, but every one has a right to know whether the claims of any newly-advertised remedy can be substantiated. In other words, it is no infringement of personal liberty to force a person who professes to have a new and valuable remedy to prove that it is at least not injurious before he shall be allowed to exploit it.

In the material world we have studied everything that grows or exists that can be marketed or used for man's sustenance or comfort, to extend his knowledge, beautify his home, or divert his leisure, but man himself in his most necessary functions, to wit, as an animal, has not been studied in any comprehensive and thorough manner, unless we may say that the Japanese have done it, since the days of Juvenal who gave us the immortal sentiment '*mens sana in corpore sano*.'

If twentieth-century civilization is to make further advance, if our beloved country is to be much longer inhabited by Americans, if in short the present Anglo-Saxon race is not to die out, steps must be taken to study the conditions of existence and ascertain what measures must be adopted to prevent the terrible waste of human life, now going on without let or hindrance. We are wasteful of many things, but of nothing else are we so wasteful as of human life. And most of this waste is entirely preventable. President Mayo said at the last meeting of the American Medical Association that a sufferer from typhoid fever has as good a right to sue the city where he contracted the filthy complaint as though he had hurt himself by a fall on a defective pavement, and yet we read in the newspapers of epidemics of typhoid fever just broken out in Cincinnati, Newark and other places. Were it outbreak of rinderpest or foot- and mouth-disease, stringent means would be at once taken to stop it and all the forces of the government would be enlisted to save cattle or sheep that have a market value. But human beings may die of typhoid fever, as our soldiers did in Camp Thomas, and no one be called to account; and yet we call ourselves a civilized and a God-fearing nation. Verily our brother's blood shall be required at our hands.

Lyman Abbott said in his baccalaureate sermon at Cambridge that we are entering a period of fraternalism: "There has been autocracy and individualism, but the new life shall be one not of socialism, nor communism, but of fraternalism." We are the keepers of our brother's body, his health, his happiness, his children and his chance to develop and to work out his destiny. We can not escape this responsibility. Knowing its duty, our government must do it and will do it.

Does any one doubt the possible value of government interference in the hygiene of daily life? If so, let him reflect on the diminished death-rate from tuberculosis since the treatment of the disease by fresh air, sunlight and an improved dietary has been so largely inaugurated. The death-rate from this disease in the United States has fallen in twenty years from about 40 per 10,000 of the population annually to about 18 per 10,000, and there is every reason to believe that it can be reduced still lower. The returns furnished in the German tuberculosis congress show a decrease of 38 per cent. in deaths from phthisis in Germany since 1875. The German insurance companies from 1901 to 1905 spent over $9,000,000 in fighting the disease and in establishing thirty-six sanatoria. These sanatoria, together with strict inspection and enforcement of sanitary regulations in that country, are believed to be the cause of the remarkable decrease in the mortality from consumption.

The diseases of the circulatory and eliminative organs, of which arterio-sclerosis may be cited as the type, are the destructive element which bear off our brain workers and educated men many years before their time. Does any one doubt that these men might live as long, as happily and usefully as Carnaro did, if they will ascertain, as he did, the physiological régime upon which their lives should be governed and act accordingly?

See what Japan, in the science of domestic hygiene certainly the most civilized nation on the globe, has accomplished in the few short years between its war with China and its war with Russia. In the former war three Japanese soldiers died from disease to one who died from wounds. This has been considered the average mortality rate of modern warfare, and so strong is prejudice and so well entrenched is error that this ratio has been looked upon as the inevitable consequence of war, whereas in the Russo-Japanese war, by the exercise of simple and perfectly feasible methods, the ratio of the mortality from sickness to that from wounds in the Japanese army assumed the proportion of one to four and one half, a difference from the accepted ratio of almost 800 per cent. No one would have believed this possible had it not been amply demonstrated. Suppose that an army of United States troops was opposed to a Japanese army. It would not be necessary for the latter to strike a blow or to fire a gun; if they could only hold our army in check for six months disease would do the rest. Do I say disease? I mean the ignorance and officialism which prevents the systematic adoption of the study of the individual soldier and the reasonable precautions which have borne such splendid results in Japan. And shall we decline to undertake similar studies in civil life because this has not been done heretofore? Did not Baron Takaki's epoch-making study of the ration in the Japanese navy stamp out beri beri in that branch of the service and enable Admiral Togo to annihilate the splendid Russian fleet?

We live as though we fully believed that man, of all living animals, is exempt from natural laws or can live superior to them. Race horses, bullocks, poultry, are reared under the strictest rules of diet and hygiene. Our children are left to ignorant nurses, or the divided counsels of improperly instructed medical men. We pass laws to prevent the children of the poor from working nights or in unwholesome surroundings, and yet we allow an overcrowded and ill-advised system of public instruction to seriously and sometimes fatally injure our own children.

There is a glaring hiatus in our educational system. The only remedy is in the proper physical education of children and the instruction of parents and teachers in the rules of proper physiological development. Rules for the development and classification of children in the public schools of Chicago have, after much painstaking labor, been pretty well worked out. These results should be collated and compared with similar results obtained in other cities and good working rules deduced from them for national application. Only a board of skilled workers under national control would have the authority, the influence and the means to formulate and apply such rules.

No doubt this proposition will meet with opposition from the stagnant elements of society, known as conservative, and from scientists falsely so-called (being in truth pedants and the greatest hinderance to all true progress). All thinking men will agree, however, that if such an investigation did nothing else, it would tend to develop the physical conscience and clarify the average conception of life. Could people generally be convinced that over-indulgence in flesh food is one of the principal causes, not alone of early decay and death, but of the almost unquenchable human appetite for alcohol and narcotics, an immense stride would have been made in human progress. And it is extremely likely that of the $600,000,000 which this country is said to spend annually in caring for its defectives and criminals, enough could be saved in a few years to carry on such an investigation as we have outlined for a lifetime. 'Science is the only true charity and the only true remedy.' Allowing degeneration, allowing intemperance, allowing immorality, gluttony and ignorance to emasculate our youth, poison the body politic, fill our penal institutions and, worst of all, prevent the proper development of our men and women, is race suicide on a scale not contemplated in ordinary family life, but multiplied by millions, and surely, unless checked, leading to national destruction and disintegration. The remedy is a proper solution of the so-called common questions of life: the neglected body, the despised dietetics, the irksome exercise must be studied by trained and accomplished experts not clinicians, not school teachers, not moralists, not sanitarians in the ordinary acceptation of the term, but specialists in humaniculture, humanists in the true sense, and these great and simple truths, which the Greeks mastered, must be learned over again in the light of modern science (not pedantry), and taught to our children's children; then shall be realized "that future where the highest art and most perfect science will be those of the development of man's faculties and aptitudes to a degree of which the Greek civilization will afford an indication instead of an unattainable ideal."

THE VALUE OF SCIENCE

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Chapter VII. The History of Mathematical Physics

The Past and the Future of Physics

WHAT is the present state of mathematical physics? What are the problems it is led to set itself? What is its future? Is its orientation about to be modified?

Ten years hence will the aim and the methods of this science appear to our immediate successors in the same light as to ourselves; or, on the contrary, are we about to witness a profound transformation? Such are the questions we are forced to raise in entering to-day upon our investigation.

If it is easy to propound them: to answer is difficult. If we felt tempted to risk a prediction, we should easily resist this temptation, by thinking of all the stupidities the most eminent savants of a hundred years ago would have uttered, if some one had asked them what the science of the nineteenth century would be. They would have thought themselves bold in their predictions, and after the event, how very timid we should have found them. Do not, therefore, expect of me any prophecy.

But if, like all prudent physicians, I shun giving a prognosis, yet I can not dispense with a little diagnostic; well, yes, there are indications of a serious crisis, as if we might expect an approaching transformation. Still, be not too anxious: we are sure the patient will not die of it, and we may even hope that this crisis will be salutary, for the history of the past seems to guarantee us this. This crisis, in fact, is not the first, and to understand it, it is important to recall those which have preceded. Pardon then a brief historical sketch.

The Physics of Central Forces

Mathematical physics, as we know, was born of celestial mechanics, which gave birth to it at the end of the eighteenth century, at the moment when it itself attained its complete development. During its first years especially the infant strikingly resembled its mother.

The astronomic universe is formed of masses, very great, no doubt, but separated by intervals so immense that they appear to us only as material points. These points attract each other inversely as the square of the distance, and this attraction is the sole force which influences their movements. But if our senses were sufficiently keen to show us all the details of the bodies which the physicist studies, the spectacle thus disclosed would scarcely differ from the one the astronomer contemplates. There also we should see material points, separated from one another by intervals, enormous in comparison with their dimensions, and describing orbits according to regular laws. These infinitesimal stars are the atoms. Like the stars proper, they attract or repel each other, and this attraction or this repulsion following the straight line which joins them, depends only on the distance. The law according to which this force varies as function of the distance is perhaps not the law of Newton, but it is an analogous law; in place of the exponent —2, we have probably a different exponent, and it is from this change of exponent that arises all the diversity of physical phenomena, the variety of qualities and of sensations, all the world, colored and sonorous, which surrounds us; in a word, all nature.

Such is the primitive conception in all its purity. It only remains to seek in the different cases what value should be given to this exponent in order to explain all the facts. It is on this model that Laplace, for example, constructed his beautiful theory of capillarity; he regards it only as a particular case of attraction, or, as he says, of universal gravitation, and no one is astonished to find it in the middle of one of the five volumes of the 'Mécanique céleste.' More recently Briot believes he penetrated the final secret of optics in demonstrating that the atoms of ether attract each other in the inverse ratio of the sixth power of the distance; and Maxwell, Maxwell himself, does he not say somewhere that the atoms of gases repel each other in the inverse ratio of the fifth power of the distance? We have the exponent —6, or —5, in place of the exponent —2, but it is always an exponent.

Among the theories of this epoch, one alone is an exception, that of Fourier; in it are indeed atoms acting at a distance one upon the other; they mutually transmit heat, but they do not attract, they never budge. From this point of view, Fourier's theory must have appeared to the eyes of his contemporaries, to those of Fourier himself, as imperfect and provisional.

This conception was not without grandeur; it was seductive, and many among us have not finally renounced it; they know that one will attain the ultimate elements of things only by patiently disentangling the complicated skein that our senses give us; that it is necessary to advance step by step, neglecting no intermediary; that our fathers were wrong in wishing to skip stations; but they believe that when one shall have arrived at these ultimate elements, there again will be found the majestic simplicity of celestial mechanics.

Neither has this conception been useless; it has rendered us an inestimable service, since it has contributed to make precise the fundamental notion of the physical law.

I will explain myself; how did the ancients understand law? It was for them an internal harmony, static, so to say, and immutable; or else it was like a model that nature tried to imitate. For us a law is something quite different; it is a constant relation between the phenomenon of to-day and that of to-morrow; in a word, it is a differential equation.

Behold the ideal form of physical law; well, it is Newton's law which first clothed it forth. If then one has acclimated this form in physics, it is precisely by copying as far as possible this law of Newton, that is by imitating celestial mechanics. This is, moreover, the idea I have tried to bring out in chapter VI.

The Physics of the Principles

Nevertheless, a day arrived when the conception of central forces no longer appeared sufficient, and this is the first of those crises of which I just now spoke.

What was done then? The attempt to penetrate into the detail of the structure of the universe, to isolate the pieces of this vast mechanism, to analyze one by one the forces which put them in motion, was abandoned, and we were content to take as guides certain general principles the express object of which is to spare us this minute study. How so? Suppose we have before us any machine; the initial wheel work and the final wheel work alone are visible, but the transmission, the intermediary machinery by which the movement is communicated from one to the other, are hidden in the interior and escape our view; we do not know whether the communication is made by gearing or by belts, by connecting-rods or by other contrivances. Do we say that it is impossible for us to understand anything about this machine so long as we are not permitted to take it to pieces? You know well we do not, and that the principle of the conservation of energy suffices to determine for us the most interesting point. We easily ascertain that the final wheel turns ten times less quickly than the initial wheel, since these two wheels are visible; we are able thence to conclude that a couple applied to the one will be balanced by a couple ten times greater applied to the other. For that there is no need to penetrate the mechanism of this equilibrium and to know how the forces compensate each other in the interior of the machine; it suffices to be assured that this compensation can not fail to occur.

Well, in regard to the universe, the principle of the conservation of energy is able to render us the same service. The universe is also a machine, much more complicated than all those of industry, of which almost all the parts are profoundly hidden from us; but in observing the motion of those that we can see, we are able, by the aid of this principle, to draw conclusions which remain true whatever may be the details of the invisible mechanism which animates them.

The principle of the conservation of energy, or Mayer's principle, is certainly the most important, but it is not the only one; there are others from which we can derive the same advantage. These are:

Carnot's principle, or the principle of the degradation of energy.

Newton's principle, or the principle of the equality of action and reaction.

The principle of relativity, according to which the laws of physical phenomena must be the same for a stationary observer as for an observer carried along in a uniform motion of translation; so that we have not and can not have any means of discerning whether or not we are carried along in such a motion.

The principle of the conservation of mass, or Lavoisier's principle.

I will add the principle of least action.

The application of these five or six general principles to the different physical phenomena is sufficient for our learning of them all that we could reasonably hope to know of them. The most remarkable example of this new mathematical physics is, beyond question, Maxwell's electromagnetic theory of light.

We know nothing as to what the ether is, how its molecules are disposed, whether they attract or repel each other; but we know that this medium transmits at the same time the optical perturbations and the electrical perturbations; we know that this transmission must take place in conformity with the general principles of mechanics, and that suffices us for the establishment of the equations of the electromagnetic field.

These principles are results of experiments boldly generalized; but they seem to derive from their very generality a high degree of certainty. In fact, the more general they are, the more frequent are the opportunities to check them, and the verifications multiplying, taking the most varied, the most unexpected forms, end by no longer leaving place for doubt.

Utility of the Old Physics.—Such is the second phase of the history of mathematical physics and we have not yet emerged from it. Shall we say that the first has been useless? that during fifty years science went the wrong way, and that there is nothing left but to forget so many accumulated efforts that a vicious conception condemned in advance to failure? Not the least in the world. Do you think the second phase could have come into existence without the first? The hypothesis of central forces contained all the principles; it involved them as necessary consequences; it involved both the conservation of energy and that of masses, and the equality of action and reaction, and the law of least action, which appeared, it is true, not as experimental truths, but as theorems; the enunciation of which had at the same time something more precise and less general than under their present form.

It is the mathematical physics of our fathers which has familiarized us little by little with these various principles; which has habituated us to recognize them under the different vestments in which they disguise themselves. They have been compared with the data of experience, it has been seen how it was necessary to modify their enunciation to adapt them to these data; thereby they have been extended and consolidated. Thus they came to be regarded as experimental truths; the conception of central forces became then a useless support, or rather an embarrassment, since it made the principles partake of its hypothetical character.

The frames then have not broken, because they are elastic; but they have enlarged; our fathers, who established them, did not labor in vain, and we recognize in the science of to-day the general traits of the sketch which they traced.

Chapter VIII. The Present Crisis of Mathematical Physics

The New Crisis.—Are we now about to enter upon a third period? Are we on the eve of a second crisis? These principles on which we have built all, are they about to crumble away in their turn? This has been for some time a pertinent question.

When I speak thus, you no doubt think of radium, that grand revolutionist of the present time, and in fact I shall come back to it presently; but there is something else. It is not alone the conservation of energy which is in question; all the other principles are equally in danger, as we shall see in passing them successively in review.

Carnot's Principle.—Let us commence with the principle of Carnot. This is the only one which does not present itself as an immediate consequence of the hypothesis of central forces; more than that, it seems, if not to directly contradict that hypothesis, at least not to be reconciled with it without a certain effort. If physical phenomena were due exclusively to the movements of atoms whose mutual attraction depended only on the distance, it seems that all these phenomena should be reversible; if all the initial velocities were reversed, these atoms, always subjected to the same forces, ought to go over their trajectories in the contrary sense, just as the earth would describe in the retrograde sense this same elliptic orbit which it describes in the direct sense, if the initial conditions of its motion had been reversed. On this account, if a physical phenomenon is possible, the inverse phenomenon should be equally so, and one should be able to reascend the course of time. Now, it is not so in nature, and this is precisely what the principle of Carnot teaches us; heat can pass from the warm body to the cold body; it is impossible afterwards to make it take the inverse route and to reestablish differences of temperature which have been effaced. Motion can be wholly dissipated and transformed into heat by friction; the contrary transformation can never be made except partially.

We have striven to reconcile this apparent contradiction. If the world tends toward uniformity, this is not because its ultimate parts, at first unlike, tend to become less and less different; it is because, shifting at random, they end by blending. For an eye which should distinguish all the elements, the variety would remain always as great; each grain of this dust preserves its originality and does not model itself on its neighbors; but as the blend becomes more and more intimate, our gross senses perceive only the uniformity. This is why, for example, temperatures tend to a level, without the possibility of going backwards.

A drop of wine falls into a glass of water; whatever may be the law of the internal motion of the liquid, we shall soon see it colored of a uniform rosy tint, and however much from this moment one may shake it afterwards, the wine and the water do not seem capable of again separating. Here we have the type of the irreversible physical phenomenon: to hide a grain of barley in a heap of wheat, this is easy; afterwards to find it again and get it out, this is practically impossible. All this Maxwell and Boltzmann have explained; but the one who has seen it most clearly, in a book too little read because it is a little difficult to read, is Gibbs, in his 'Elementary Principles of Statistical Mechanics.'

For those who take this point of view, Carnot's principle is only an imperfect principle, a sort of concession to the infirmity of our senses; it is because our eyes are too gross that we do not distinguish the elements of the blend; it is because our hands are too gross that we can not force them to separate; the imaginary demon of Maxwell, who is able to sort the molecules one by one, could well constrain the world to return backward. Can it return of itself? That is not impossible; that is only infinitely improbable. The chances are that we should wait a long time for the concourse of circumstances which would permit a retrogradation; but sooner or later they will occur, after years whose number it would take millions of figures to write. These reservations, however, all remained theoretic; they were not very disquieting, and Carnot's principle retained all its principal value. But here the scene changes. The biologist, armed with his microscope, long ago noticed in his preparations irregular movements of little particles in suspension; this is the Brownian movement. He first thought this was a vital phenomenon, but soon he saw that the inanimate bodies danced with no less ardor than the others; then he turned the matter over to the physicists. Unhappily, the physicists remained long uninterested in this question; one concentrates the light to illuminate the microscopic preparation, thought they; with light goes heat; thence inequalities of temperature and in the liquid interior currents which produce the movements referred to.

It occurred to M. Gouy to look more closely, and he saw, or thought he saw, that this explanation is untenable, that the movements become brisker as the particles are smaller, but that they are not influenced by the mode of illumination. If then these movements never cease, or rather are reborn without cease, without borrowing anything from an external source of energy, what ought we to believe? To be sure, we should not on this account renounce our belief in the conservation of energy, but we see under our eyes now motion transformed into heat by friction, now inversely heat changed into motion, and that without loss since the movement lasts forever. This is the contrary of Carnot's principle. If this be so, to see the world return backward, we no longer have need of the infinitely keen eye of Maxwell's demon; our microscope suffices. Bodies too large, those, for example, which are a tenth of a millimeter, are hit from all sides by moving atoms, but they do not budge, because these shocks are very numerous and the law of chance makes them compensate each other; but the smaller particles receive too few shocks for this compensation to take place with certainty and are incessantly knocked about. And behold already one of our principles in peril.

The Principle of Relativity.—Let us pass to the principle of relativity: this not only is confirmed by daily experience, not only is it a necessary consequence of the hypothesis of central forces, but it is irresistibly imposed upon our good sense, and yet it also is assailed. Consider two electrified bodies; though they seem to us at rest, they are both carried along by the motion of the earth; an electric charge in motion, Rowland has taught us, is equivalent to a current; these two charged bodies are, therefore, equivalent to two parallel currents of the same sense and these two currents should attract each other. In measuring this attraction, we shall measure the velocity of the earth; not its velocity in relation to the sun or the fixed stars, but its absolute velocity.

I well know what will be said: It is not its absolute velocity that is measured, it is its velocity in relation to the ether. How unsatisfactory that is! Is it not evident that from the principle so understood we could no longer infer anything? It could no longer tell us anything just because it would no longer fear any contradiction. If we succeed in measuring anything, we shall always be free to say that this is not the absolute velocity, and if it is not the velocity in relation to the ether, it might always be the velocity in relation to some new unknown fluid with which we might fill space.

Indeed, experiment has taken upon itself to ruin this interpretation of the principle of relativity; all attempts to measure the velocity of the earth in relation to the ether have led to negative results. This time experimental physics has been more faithful to the principle than mathematical physics; the theorists, to put in accord their other general views, would not have spared it; but experiment has been stubborn in confirming it. The means have been varied; finally Michelson pushed precision to its last limits; nothing came of it. It is precisely to explain this obstinacy that the mathematicians are forced to-day to employ all their ingenuity.

Their task was not easy, and if Lorentz has got through it, it is only by accumulating hypotheses.

The most ingenious idea was that of local time. Imagine two observers who wish to adjust their timepieces by optical signals; they exchange signals, but as they know that the transmission of light is not instantaneous, they are careful to cross them. When station B perceives the signal from station A, its clock should not mark the same hour as that of station A at the moment of sending the signal, but this hour augmented by a constant representing the duration of the transmission. Suppose, for example, that station A sends its signal when its clock marks the hour *O,* and that station B perceives it when its clock marks the hour t. The clocks are adjusted if the slowness equal to t represents the duration of the transmission, and to verify it, station B sends in its turn a signal when its clock marks *O;* then station A should perceive it when its clock marks t. The timepieces are then adjusted.

And in fact they mark the same hour at the same physical instant, but on the one condition, that the two stations are fixed. Otherwise the duration of the transmission will not be the same in the two senses, since the station A, for example, moves forward to meet the optical perturbation emanating from B, whereas the station B flees before the perturbation emanating from A. The watches adjusted in that way will not mark, therefore, the true time; they will mark what may be called the *local time,* so that one of them will gain on the other. It matters little, since we have no means of perceiving it. All the phenomena which happen at A, for example, will be late, but all will be equally so, and the observer will not perceive it, since his watch is slow; so, as the principle of relativity would have it, he will have no means of knowing whether he is at rest or in absolute motion.

Unhappily, that does not suffice, and complementary hypotheses are necessary; it is necessary to admit that bodies in motion undergo a uniform contraction in the sense of the motion. One of the diameters of the earth, for example, is shrunk by one two-hundred-millionth in consequence of our planet's motion, while the other diameter retains its normal length. Thus the last little differences are compensated. And then, there is still the hypothesis about forces. Forces, whatever be their origin, gravity as well as elasticity, would be reduced in a certain proportion in a world animated by a uniform translation; or, rather, this would happen for the components perpendicular to the translation; the components parallel would not change. Resume, then, our example of two electrified bodies; these bodies repel each other, but at the same time if all is carried along in a uniform translation, they are equivalent to two parallel currents of the same sense which attract each other. This electrodynamic attraction diminishes, therefore, the electrostatic repulsion, and the total repulsion is feebler than if the two bodies were at rest. But since to measure this repulsion we must balance it by another force, and all these other forces are reduced in the same proportion, we perceive nothing. Thus, all seems arranged, but are all the doubts dissipated? What would happen if one could communicate by non-luminous signals whose velocity of propagation differed from that of light? If, after having adjusted the watches by the optical procedure, we wished to verify the adjustment by the aid of these new signals, we should observe discrepancies which would render evident the common translation of the two stations. And are such signals inconceivable, if we admit with Laplace that universal gravitation is transmitted a million times more rapidly than light?

Thus, the principle of relativity has been valiantly defended in these latter times, but the very energy of the defense proves how serious was the attack.

Newton's Principle.—Let us speak now of the principle of Newton, on the equality of action and reaction. This is intimately bound up with the preceding, and it seems indeed that the fall of the one would involve that of the other. Thus we must not be astonished to find here the same difficulties.

Electrical phenomena, according to the theory of Lorentz, are due to the displacements of little charged particles, called electrons, immersed in the medium we call ether. The movements of these electrons produce perturbations in the neighboring ether; these perturbations propagate themselves in every direction with the velocity of light, and in turn other electrons, originally at rest, are made to vibrate when the perturbation reaches the parts of the ether which touch them. The electrons, therefore, act on one another, but this action is not direct, it is accomplished through the ether as intermediary. Under these conditions can there be compensation between action and reaction, at least for an observer who should take account only of the movements of matter, that is, of the electrons, and who should be ignorant of those of the ether that he could not see? Evidently not. Even if the compensation should be exact, it could not be simultaneous. The perturbation is propagated with a finite velocity; it, therefore, reaches the second electron only when the first has long ago entered upon its rest. This second electron, therefore, will undergo, after a delay, the action of the first, but will certainly not at that moment react upon it, since around this first electron nothing any longer budges.

The analysis of the facts permits us to be still more precise. Imagine, for example, a Hertzian oscillator, like those used in wireless telegraphy; it sends out energy in every direction; but we can provide it with a parabolic mirror, as Hertz did with his smallest oscillators, so as to send all the energy produced in a single direction. What happens then according to the theory? The apparatus recoils, as if it were a cannon and the projected energy a ball; and that is contrary to the principle of Newton, since our projectile here has no mass, it is not matter, it is energy. The case is still the same, moreover, with a beacon light provided with a reflector, since light is nothing but a perturbation of the electromagnetic field. This beacon light should recoil as if the light it sends out were a projectile. What is the force that should produce this recoil? It is what is called Maxwell-Bartholdi pressure. It is very minute, and it has been difficult to put it in evidence even with the most sensitive radiometers; but it suffices that it exists.

If all the energy issuing from our oscillator falls on a receiver, this will act as if it had received a mechanical shock, which will represent in a sense the compensation of the oscillator's recoil; the reaction will be equal to the action, but it will not be simultaneous; the receiver will move on, but not at the moment when the oscillator recoils. If the energy propagates itself indefinitely without encountering a receiver, the compensation will never occur.

Shall we say that the space which separates the oscillator from the receiver and which the perturbation must pass over in going from the one to the other is not void, that it is full not only of ether, but of air, or even in the interplanetary spaces of some fluid subtile but still ponderable; that this matter undergoes the shock like the receiver at the moment when the energy reaches it, and recoils in its turn when the perturbation quits it? That would save Newton's principle, but that is not true. If energy in its diffusion remained always attached to some material substratum, then matter in motion would carry along light with it, and Fizeau has demonstrated that it does nothing of the sort, at least for air. Michelson and Morley have since confirmed this.

It might be supposed also that the movements of matter proper are exactly compensated by those of the ether; but that would lead us to the same reflections as before now. The principle so understood will explain everything, since, whatever might be the visible movements, we always could imagine hypothetical movements which compensate them. But if it is able to explain everything, this is because it does not enable us to foresee anything; it does not enable us to decide between the different possible hypotheses, since it explains everything beforehand. It therefore becomes useless.

And then the suppositions that it would be necessary to make on the movements of the ether are not very satisfactory. If the electric charges double, it would be natural to imagine that the velocities of the diverse atoms of ether double also, and for the compensation, it would be necessary that the mean velocity of the ether quadruple.

This is why I have long thought that these consequences of theory, contrary to Newton's principle, would end some day by being abandoned, and yet the recent experiments on the movements of the electrons issuing from radium seem rather to confirm them.

Lavoisier's Principle.—I arrive at the principle of Lavoisier on the conservation of mass. Certainly, this is one not to be touched without unsettling all mechanics. And now certain persons think that it seems true to us only because in mechanics merely moderate velocities are considered, but that it would cease to be true for bodies animated by velocities comparable to that of light. Now these velocities, it is believed at present, have been realized; the cathode rays or those of radium may be formed of very minute particles or of electrons which are displaced with velocities smaller no doubt than that of light, but which might be its one tenth or one third.

These rays can be deflected, whether by an electric field, or by a magnetic field, and we are able, by comparing these deflections, to measure at the same time the velocity of the electrons and their mass (or rather the relation of their mass to their charge). But when it was seen that these velocities approached that of light, it was decided that a correction was necessary. These molecules, being electrified, can not be displaced without agitating the ether; to put them in motion it is necessary to overcome a double inertia, that of the molecule itself and that of the ether. The total or apparent mass that one measures is composed, therefore, of two parts: the real or mechanical mass of the molecule and the electrodynamic mass representing the inertia of the ether.

The calculations of Abraham and the experiments of Kaufmann have then shown that the mechanical mass, properly so called, is null, and that the mass of the electrons, or, at least, of the negative electrons, is of exclusively electrodynamic origin. This is what forces us to change the definition of mass; we can not any longer distinguish mechanical mass and electrodynamic mass, since then the first would vanish; there is no mass other than electrodynamic inertia. But in this case the mass can no longer be constant; it augments with the velocity, and it even depends on the direction, and a body animated by a notable velocity will not oppose the same inertia to the forces which tend to deflect it from its route, as to those which tend to accelerate or to retard its progress.

There is still a resource; the ultimate elements of bodies are electrons, some charged negatively, the others charged positively. The negative electrons have no mass, this is understood; but the positive electrons, from the little we know of them, seem much greater. Perhaps they have, besides their electrodynamic mass, a true mechanical mass. The real mass of a body would, then, be the sum of the mechanical masses of its positive electrons, the negative electrons not counting; mass so defined might still be constant.

Alas! this resource also evades us. Recall what we have said of the principle of relativity and of the efforts made to save it. And it is not merely a principle which it is a question of saving, it is the indubitable results of the experiments of Michelson.

Well, as was above seen, Lorentz, to account for these results, was obliged to suppose that all forces, whatever their origin, were reduced in the same proportion in a medium animated by a uniform translation; this is not sufficient; it is not enough that this take place for the real forces, it must also be the same for the forces of inertia; it is therefore necessary, he says, that *the masses of all the particles be influenced by a translation to the same degree as the electromagnetic masses of the electrons.*

So the mechanical masses must vary in accordance with the same laws as the electrodynamic masses; they can not, therefore, be constant.

Need I point out that the fall of Lavoisier's principle involves that of Newton's? This latter signifies that the center of gravity of an isolated system moves in a straight line; but if there is no longer a constant mass, there is no longer a center of gravity, we no longer know even what this is. This is why I said above that the experiments on the cathode rays appeared to justify the doubts of Lorentz concerning Newton's principle.

From all these results, if they were confirmed, would arise an entirely new mechanics, which would be, above all, characterized by this fact, that no velocity could surpass that of light,[1] any more than any temperature can fall below absolute zero.

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[1] Because bodies would oppose an increasing inertia to the causes which would tend to accelerate their motion; and this inertia would become infinite when one approached the velocity of light.

No more for an observer, carried along himself in a translation he does not suspect, could any apparent velocity surpass that of light; and this would be then a contradiction, if we did not recall that this observer would not use the same clocks as a fixed observer, but, indeed, clocks marking 'local time.'

Here we are then facing a question I content myself with stating. If there is no longer any mass, what becomes of Newton's law? Mass has two aspects: it is at the same time a coefficient of inertia and an attracting mass entering as factor into Newtonian attraction. If the coefficient of inertia is not constant, can the attracting mass be? That is the question.

Mayer's Principle.—At least, the principle of the conservation of energy yet remained to us, and this seemed more solid. Shall I recall to you how it was in its turn thrown into discredit? This event has made more noise than the preceding, and it is in all the memoirs. From the first works of Becquerel, and, above all, when the Curies had discovered radium, it was seen that every radioactive body was an inexhaustible source of radiation. Its activity seemed to subsist without alteration throughout the months and the years. This was in itself a strain on the principles; these radiations were in fact energy, and from the same morsel of radium this issued and forever issued. But these quantities of energy were too slight to be measured; at least that was the belief and we were not much disquieted.

The scene changed when Curie bethought himself to put radium in a calorimeter; it was then seen that the quantity of heat incessantly created was very notable.

The explanations proposed were numerous; but in such case we can not say, 'store is no sore.' In so far as no one of them has prevailed over the others, we can not be sure there is a good one among them. Since some time, however, one of these explanations seems to be getting the upper hand and we may reasonably hope that we hold the key to the mystery.

Sir W. Ramsay has striven to show that radium is in process of transformation, that it contains a store of energy enormous but not inexhaustible. The transformation of radium then would produce a million times more heat than all known transformations; radium would wear itself out in 1,250 years; this is quite short, and you see that we are at least certain to have this point settled some hundreds of years from now. While waiting, our doubts remain.

A DEFENCE OF PRAGMATISM[1]

II. What Pragmatism Means

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SOME years ago, being with a camping party in the mountains, I returned from a solitary ramble to find every one engaged in a ferocious metaphysical dispute. The *corpus* of the dispute was a squirrel—a live squirrel supposed to be clinging to one side of a tree-trunk; while over against the tree's opposite side a human being was imagined to stand. This human witness tries to get sight of the squirrel by moving rapidly round the tree, but no matter how fast he goes, the squirrel moves as fast in the opposite direction, and always keeps the tree between himself and the man, so that never a glimpse of him is caught. The resultant metaphysical problem now is this: *Does the man go round the squirrel or not?* He goes round the tree, sure enough, and the squirrel is on the tree; but does he go round the squirrel? In the unlimited leisure of the wilderness, discussion had been worn threadbare. Every one had taken sides, and was obstinate, and the numbers on both sides were even. Each side, when I appeared, therefore, appealed to me to make it a majority. Mindful of the scholastic adage that whenever you meet a contradiction you must make a distinction, I immediately sought and found one, as follows: "Which party is right," I said, "depends on what you *practically mean* by 'going round' the squirrel. If you mean passing from the north of him to the east, then to the south, then to the west, and then to the north of him again, obviously the man does go round him, for he occupies these successive positions. But if, on the contrary, you mean being first in front of him, then on the right of him, then behind him, then on his left, and finally in front again, it is quite as obvious that the man fails to go round him, for by the compensating movements the squirrel makes, he keeps his belly turned towards the man all the time, and his back turned away. Make the distinction, and there is no occasion for any further dispute. You are both right and both wrong according as you conceive the verb 'to go round' in one way or another practical fashion."

Although one or two of the hotter disputants called my speech a

[1] The second of a course of eight lectures on 'Pragmatism: A New Name for an Old Way of Thinking,' given before the Lowell Institute, Boston, and the Departments of Philosophy and Psychology, Columbia University.

shuffling evasion, saying they wanted no quibbling or scholastic hair-splitting, but meant just plain honest English 'round,' the majority seemed to think that the distinction had assuaged the dispute.

I tell this trivial anecdote because it is a peculiarly simple example of what I wish now to speak of as *the pragmatic method.*[1] The pragmatic method is primarily a method of settling metaphysical disputes that otherwise might be interminable. Is the world one or many?—fated or free?—material or spiritual?—here are notions either of which may or may not hold good of the world; and disputes over such notions are unending. The pragmatic method in such cases is to try to interpret each notion by tracing its respective practical consequences. What difference would it practically make to any one if this notion rather than that one were true? If no practical difference whatever can be traced, then the alternatives mean practically the same thing, and all dispute is idle. Whenever a dispute is serious, we ought to be able to show some practical difference that must follow from one side or the other's being right.

A glance at the history of the idea will show you still better what pragmatism means. The word is derived from the same Greek term πραγμα, meaning action, from which our words 'practise' and 'practical' come. It was first introduced into philosophy by Mr. Charles Peirce in 1878. In an article in the POPULAR SCIENCE MONTHLY for that year[2] Mr. Peirce, after pointing out that our beliefs are really rules for action, said that, to develop a thought's meaning, we need only determine what conduct it is fitted to produce; that conduct is for us its sole significance. And the tangible fact at the root of all our thought-distinctions, however subtle, is that there is no one of them so fine as to consist in anything but a possible difference of practise. To attain perfect clearness in our thoughts of an object, then, we need only consider what effects of a conceivably practical kind the object may involve—what sensations we are to expect from it, and what reactions we must prepare. Our conception of these effects, whether immediate or remote, is then for us the whole of our conception of the object, so far as that conception has positive significance at all.

This is the principle of Peirce, the principle of pragmatism. It lay entirely unnoticed by any one for twenty years, until I, in an address before Professor Howison's Philosophical Union at the University of California, brought it forward again, quoting Peirce, and making a certain application of it to religion. By that date (1898) the times seemed ripe for its reception. The word 'pragmatism' spread, and at present it fairly spots the pages of the philosophic journals. On all hands we find the 'pragmatic movement' spoken of, sometimes with respect, sometimes with contumely, seldom with clear understanding.

[2] January, 1878, 'How to Make Our Ideas Clear.'

It is evident that the term applies itself conveniently to a number of tendencies that hitherto have lacked a collective name, and that it has 'come to stay.'

To take in the importance of Peirce's principle, one must get accustomed to applying it to concrete cases. I found a few years ago that Ostwald, the illustrious Leipzig chemist, had been making perfectly distinct use of the principle of pragmatism in his lectures on the philosophy of science, though he had not called it by that name.

"All realities influence our practise," he wrote me, "and that influence is their meaning for us. I am accustomed to put questions to my classes in this way: In what respects would the world be different if this alternative or that were true? If I can find nothing that would become different, then the alternative has no sense."

That is, the rival views mean practically the same thing, and meaning, other than practical, there is for us none. Ostwald in a published lecture gives this example of what he means. Chemists have long wrangled over the inner constitution of certain bodies called 'tautomerous.' Their properties seemed equally consistent with the notion that an instable hydrogen atom oscillates inside of them, or that they are instable mixtures of two bodies. Controversy raged; but never was decided. "It would never have begun," says Ostwald, "if the combatants had asked themselves what particular experimental fact could have been made different by one or the other view being correct. For it would then have appeared that no difference of fact could possibly ensue; and the quarrel was as unreal as if, theorizing in old times about the raising of dough by yeast, one party should have invoked a 'brownie,' while another insisted on a 'fairy' as the true cause of the phenomenon."[3]

It is astonishing to see how many philosophical disputes collapse into insignificance the moment you subject them to this simple test of tracing a concrete consequence. There can *be* no difference anywhere that doesn't *make* a difference elsewhere—no difference in abstract truth that doesn't express itself in a difference in concrete fact and in conduct consequent upon that fact, imposed on somebody, somehow, somewhere and somewhen. The whole function of philosophy ought to be to find out what definite difference it will make to you and me, at definite instants of our life, if this world-formula or that world-formula be the true one.

[3] 'Theorie und Praxis,' *Zeitsch. des Oesterreichischen Ingenieur u. Architecten-Vereines*, 1905, Nr. 4 u. 6. I find a still more radical pragmatism than Ostwald's in an address by Professor W. S. Franklin: "I think that the sickliest notion of physics, even if a student gets it, is that it is 'the science of masses, molecules and the ether.' And I think that the healthiest notion, even if a student does not wholly get it, is that physics is the science of the ways of taking hold of bodies and pushing them!" (*Science*, January 2, 1903.)

There is absolutely nothing new in the pragmatic method. Socrates was an adept at it. Aristotle used it methodically. Locke, Berkeley and Hume made momentous contributions to truth by its means. Shadworth Hodgson keeps insisting that realities are only what they are 'known as.' But these forerunners of pragmatism used it in fragments. They were a prelude only. Only in our time has it generalized itself, become conscious of a universal mission, pretended to a conquering destiny. I believe in that destiny, and I hope I may end by inspiring you with my belief.

Pragmatism represents a perfectly familiar attitude in philosophy, the empiricist attitude, but it represents it, as it seems to me, both in a more radical, and in a less objectionable form than it has ever yet assumed. A pragmatist turns his back resolutely and once for all upon a lot of inveterate habits dear to professional philosophers. He turns away from abstraction and insufficiency, from verbal solutions, from bad *a priori* reasons, from fixed principles, closed systems, and pretended absolutes and origins. He turns towards concreteness and adequacy, towards facts, towards action, towards power. That means the empiricist temper regnant, and the rationalist temper sincerely given up. It means the open air and possibilities of nature, as against dogma, artificiality and the pretence of finality in truth.

At the same time it does not stand for any special results. It is a method only. But the general triumph of that method would mean an enormous change in what I called in my last lecture the 'temperament' of philosophy. Teachers of the ultra-rationalistic type would be frozen out, much as the courtier type is frozen out in republics, as the ultramontane type of priest is frozen out in protestant lands. Science and metaphysics would come much nearer together, would in fact work absolutely hand in hand.

Metaphysics has usually followed a very primitive kind of quest. You know how men have always hankered after unlawful magic, and you know what a great part, in magic, *words* have always played. If you have his name, or the formula of incantation that binds him, you can control the spirit, genie, afrite, or whatever the power may be. Solomon knew the names of all the spirits, and knowing their names, he held them subject to his will. So the universe has always appeared to the natural mind as a kind of enigma, of which the key must be sought in the shape of some illuminating word or some power-bringing word or name. That word names the universe's *Principle,* and to possess it is, after a fashion, to possess the universe itself. 'God,' 'Matter,' 'Reason,' 'the Absolute,' 'Energy,' are so many solving names. You can rest when you have them. You are at the end of your metaphysical quest.

But if you follow the pragmatic method, you can not look on any such word as closing your quest. You must bring out of each word its practical cash-value, set it at work within the stream of your experience. It appears less as a solution, then, than as a program for more work.

Theories thus become *instruments,* not answers to enigmas, in which we can rest. We don't lie back upon them, we move forward by their aid. Pragmatism unstiffens all our theories, limbers them up and sets each one at work. Being nothing essentially new, it harmonizes with many ancient philosophic tendencies. It agrees with nominalism, for instance, in always appealing to particulars; with utilitarianism in emphasizing practical aspects; with positivism in its disdain for verbal solutions, useless questions, and metaphysical abstractions.

All these, you see, are *anti-intellectualist* tendencies. Against rationalism as a pretension and a method, pragmatism is fully armed and militant. But, at the outset, at least, it stands for no particular results. It has no dogmas, and no doctrines save its method. As the young Italian pragmatist Papini has well said, it lies in the midst of our theories, like a corridor in a hotel. Innumerable chambers open out of it. In one you may find a man writing an atheistic volume; in the next, some one on his knees praying for faith and strength; in a third a chemist investigating a body's properties. In a fourth a system of idealistic metaphysics is being excogitated; in a fifth the impossibility of metaphysics is being shown. But they all own the corridor, and all must pass through it if they want a practicable way of getting into or out of their respective rooms.

No particular results then, so far, but only an attitude of orientation, is what the pragmatic method means. The attitude of looking away from first things, principles, 'categories,' supposed necessities; and of looking towards last things, fruits, consequences, facts.

So much for the pragmatic method! Meanwhile the word pragmatism has come to be used in a still wider sense, as meaning also a certain *theory of truth.* I ask for your redoubled attention here. If much remains obscure, I hope to make it clearer in the later lectures.

One of the most successfully cultivated branches of philosophy in our time is what is called inductive logic, the study of the conditions under which our sciences have evolved. Writers on this subject have begun to show a singular unanimity as to what the laws of nature and elements of fact mean, when formulated by mathematicians, physicists and chemists. When the first mathematical, logical and natural uniformities, the first *laws,* were discovered, men were so carried away by the clearness, beauty and simplification that resulted, that they believed themselves to have deciphered authentically the eternal thoughts of the Almighty. *His* mind also reverberated in syllogisms. He also thought in conic sections, squares and roots, and ratios, and geometrized like Euclid. He made Kepler's laws for the planets to follow; he made velocity increase proportionally to the time in falling bodies; he made the laws of the sines for light to obey when refracted; he established the classes, orders, families and genera of plants and animals, and fixed the distances between them. He thought the archetypes of all things, and devised their variations; and when we re-discover any one of these his wondrous institutions, we seize his mind in its very literal intention.

But as the sciences have developed farther, the notion has gained ground that most, perhaps all, of our laws are only approximations. The laws themselves, moreover, have grown so numerous that there is no counting them; and so many rival formulations are proposed in all the branches of science that investigators have become accustomed to the notion that no theory is absolutely a transcript of reality, but that any one of them may from some point of view be useful. Their great use is to summarize old facts and to lead to new ones. They are only a man-made language, a conceptual shorthand, as Pearson calls them, in which we write our reports of nature; and languages, as is well known, tolerate much choice of expression and many dialects.

Thus human arbitrariness has driven divine necessity from scientific logic. If I mention the names of Sigwart, Mach, Ostwald, Pearson, Milhaud, Poincaré, Duhem, Heymans, those of you who are students will easily identify the tendency I speak of, and will think of additional names.

Riding now on the front of this wave of scientific logic Messrs. Schiller and Dewey appear with their pragmatistic account of what truth everywhere signifies. Everywhere, these men say, 'truth' in our ideas and beliefs means the same thing that it means in science. It means, they suggest, nothing but this, that ideas become true just in so far as they help us to get into satisfactory relation with the other parts of our experience, to synthesize and summarize facts and other ideas, and get about among them by conceptual short-cuts instead of following the interminable labyrinth of particular phenomena as they succeed one another. Any idea upon which we can ride, so to speak; any idea that will carry us prosperously from any one part of our experience to any other part; linking things satisfactorily, working securely, simplifying, saving labor, is true for just so much, true in so far forth, true *instrumentally*. This is the 'instrumental' view of truth taught so successfully at Chicago, the view that truth means the power of our ideas to 'work,' promulgated so brilliantly at Oxford.

Messrs. Dewey, Schiller and their allies, in reaching this general notion of all truth, have only followed the example of geologists, biologists and philologists. In the establishment of these other sciences, the successful stroke was always to take some simple process actually observable in operation—as denudation by weather, say, or variation from parental type, or change of dialect by incorporation of new words and pronunciations—and then to generalize it, to make it apply to all times, and produce great results by summating its effects through ages.

The process which Schiller and Dewey particularly singled out for generalization is the familiar one by which any individual *settles into new opinions.* The process here is always the same. The individual has a stock of old opinions already, but he meets a new experience that puts them to a strain. Somebody contradicts them; or in a reflective moment he discovers that they contradict each other; or he hears of facts with which they are incompatible; or desires arise in him which they cease to satisfy. The result is an inward trouble to which his mind till then had been a stranger, and from which he seeks to escape by modifying his previous mass of opinions. He saves as much of it as he can, for in this matter of belief we are all extreme conservatives. So he tries to change first this opinion, and then that (for they resist change very variously), until at last some new idea comes up which he can graft upon the ancient stock with a minimum of disturbance of the latter, some idea that mediates between the stock and the new experience and runs them into one another most felicitously and expediently.

This new idea is then adopted as the true one. It preserves the older stock of truths with a minimum of modification, stretching them just enough to make them admit the novelty and conceiving that in ways as familiar as the case leaves possible. An *outrée* explanation, violating all our preconceptions, would never pass for a true account of a novelty. We should scratch round industriously till we found something less excentric. The most violent revolutions in an individual's beliefs leave most of his old order standing. Time and space, cause and effect, nature and history, and one's own biography remain untouched. New truth is always a go-between, a smoother-over of transitions. It marries old opinion to new fact so as ever to show a minimum of jolt, a maximum of continuity. We hold a theory true just in proportion to its success in solving this 'problem of maxima and minima.' But success in solving this problem is eminently a matter of approximation. We say this theory solves it on the whole more satisfactorily than that theory; but that means more satisfactorily to ourselves, and individuals will emphasize their points of satisfaction differently. To a certain degree, therefore, everything here is plastic.

The point I now urge you to observe particularly is the part played by the older truths. Failure to take account of it is the source of many of the unjust criticisms leveled against pragmatism. The influence of elder truths is absolutely controlling. Loyalty to them is the first principle—in most cases it is the only principle. The most usual way of handling phenomena so novel that they would make for a serious rearrangement of our preconceptions is to ignore them altogether, or to abuse those who bear witness for them.

You doubtless wish examples of this process of truth's growth, and the only trouble is their superabundance. The simplest case of new truth is of course the mere numerical addition of new kinds of fact, or of new facts of old kinds, to our experience—an addition that involves no alteration in the old beliefs. Day follows day, and its contents are simply added. The new contents themselves are not true, they simply *come* and *are*. Truth is *what we say about* them, and when we say that they have come, truth is satisfied by the plain additive formula.

But often the day's contents oblige a rearrangement. If I should now utter piercing shrieks and act like a maniac on this platform, it would make many of you revise your ideas as to the probable worth of my philosophy. 'Radium' came the other day as part of the day's content, and seemed for a moment to contradict our ideas of the whole order of nature, that order having come to be identified with what is called the conservation of energy. The mere sight of radium paying heat away indefinitely out of its own pocket, seemed to violate that conservation. What to think? If the radiations from it were nothing but an escape of unsuspected 'potential' energy, preexistent inside the atoms, the principle of conservation would be saved. The discovery of 'helium' as the radiation's outcome, opened a way to this belief. So Ramsay's view is generally held to be true, because, although it extends our old ideas of energy, it causes a minimum of alteration in their nature.

I need not multiply instances. A new opinion counts as 'true' just in proportion as it gratifies the individual's desire to assimilate the novel in his experience to his beliefs-in-stock. It must both lean on old truth and grasp new fact; and its success (as I said a moment ago), in doing this, is a matter for the individual's appreciation. When old truth grows, then, by new truth's addition, it is for subjective reasons. We are in the process and obey the reasons. That new idea is truest which performs most felicitously its function of satisfying our double urgency. It *makes* itself true, gets itself classed as true, by the way it works; grafting itself then upon the ancient body of truth, which grows, thus, much as a tree grows by the activity of a new layer of cambium.

Now Dewey and Schiller proceed to generalize this observation and to apply it to the most ancient parts of truth. They also once were plastic. They also were called true for human reasons. They also mediated between still earlier truths and what in those days were novel observations. Purely objective truth, truth in whose establishment the function of giving human satisfaction in marrying one part of experience with another played no part whatever, is nowhere to be found. The reason why we call things true is the reason why they *are* true, for 'to be true' *means* only to perform this marriage function.

The trail of the human serpent is thus over everything. Truth independent; truth that we *find* merely; truth no longer malleable to human need; truth incorrigible, in a word; such truth exists indeed superabundantly—or is supposed to exist by rationalistic-minded thinkers. But that means only the dead heart of the living tree, it means only that truth also has its paleontology, and may grow stiff with years of veteran service and petrified in men's regard by sheer antiquity. How plastic even the oldest truths still really are has been vividly shown in our day by the transformation of logical and mathematical ideas, a transformation which seems even to be invading physics. The ancient formulas are reinterpreted as special expressions of much wider principles, principles that our ancestors never got a glimpse of in their present formulation.

Mr. Schiller gives to all this view of truth the name of 'Humanism,' but, for this doctrine too, the name of pragmatism seems to be in the ascendant, not only in America but on the European continent, so I must treat it also in these lectures.[4]

Such then would be the scope of pragmatism—a method and a genetic theory of what is meant by truth. And these two things must be our future topics.

What I have said of the theory of truth will, I am sure, have appeared obscure and unsatisfactory to most of you by reason of its brevity. You may not follow me wholly in this preliminary lecture; and if you do, you may not wholly agree with me. But you will, I know, already regard me at least as serious, and treat my effort with respectful consideration.

You will probably be surprised to learn, then, that Messrs. Schiller's and Dewey's theories have suffered a hailstorm of contempt and ridicule. All rationalism has risen against them. In influential quarters Mr. Schiller, in particular, has been treated like an impudent schoolboy who deserved a spanking. I shouldn't mention this, but for the fact that it throws so much side-light upon that rationalistic temper to which I have opposed the temper of pragmatism. Pragmatism is uncomfortable away from facts. Rationalism is comfortable only in the presence of abstractions. This pragmatist talk about truths in the plural, about their utility and satisfactoriness, about the success with which they 'work,' etc., suggests to the typical intellectualist mind a sort of coarse lame makeshift article of truth. Such truths are not real

[4] Even while I correct the proof I receive Mr. Schiller's new volume, 'Studies in Humanism,' N. Y. The Macmillan Company, pp. 492. The title shows that Mr. Schiller still clings to his term.

truth. Such tests are merely subjective. As against this, objective truth must be something non-utilitarian, haughty, refined, remote, august, exalted. It must be an absolute correspondence of our thoughts with an equally absolute reality. It must be what we *ought* to think, unconditionally. The ways in which we *do* think are so much irrelevance and matter for psychology. Down with psychology, up with logic, in all this question!

See the exquisite contrast of the types of mind! The pragmatist clings to facts and concreteness, observes truth at its work in particular cases, and generalizes. Truth, for him, becomes a class-name for definite working values in experience. For the rationalist it remains a pure abstraction, to the bare name of which we must defer. When the pragmatist undertakes to show in detail just *why* we must defer, the rationalist is unable to recognize the concretes from which his own abstraction is taken. He accuses us of *denying* truth, whereas we have only sought to trace exactly why people follow it and always ought to follow it. Your typical ultra-abstractionist fairly shudders at concreteness. Other things equal, he positively prefers the pale and spectral. If the two universes were offered, he would always choose the skinny outline rather than the rich thicket of reality. It is so much purer, clearer, nobler.

I hope that as these lectures go on, the concreteness and closeness to facts of the pragmatism which they advocate may be what approves itself to you as its most satisfactory peculiarity. It only follows here the example of the sister sciences, interpreting the unobserved by the observed. It brings old and new harmoniously together. It converts the absolutely empty notion of a bare static relation of 'correspondence' (whatever that may mean) between our minds and reality, into that of a rich and active commerce, that any one may follow in detail and understand, between particular thoughts of ours, and the great universe of other experiences in which they play their parts and have their uses.

But enough of this at present? The justification of what I say must be postponed. I wish now to add a word in further explanation of the claim I made at our last meeting, that pragmatism may be a happy harmonizer of empiricist ways of thinking, with the more religious demands of human beings.

Men who are strongly of the fact-loving temperament, you may remember me to have said, are liable to be kept at a distance by the unsympathetic tone of the philosophy which present-day idealism offers them. It is too intellectualistic for them. Old-fashioned dualistic theism was bad enough, with its notion of God as an exalted monarch, made up of a lot of unintelligible or preposterous 'attributes'; but, so long as it held strongly by the argument from design, it kept some touch with concrete realities. Since, however, Darwinism has once for all displaced design from the minds of the 'scientific,' theism has lost that foothold; and some kind of an immanent or pantheistic deity working *in* things rather than above them is, if any, the kind desired by our contemporary imagination. Aspirants to a philosophic religion turn, as a rule, more hopefully nowadays towards idealistic pantheism than towards the older dualistic theism, in spite of the fact that the latter still counts able defenders.

But, as I said in my first lecture, the brand of pantheism offered is hard for them to assimilate if they are lovers of facts, or empirically minded. It is the absolutistic brand, spurning the dust and reared upon pure logic. It keeps no connection whatever with concreteness. Affirming the Absolute Mind, which is its substitute for God, to be the rational presupposition of all particulars of fact, whatever they may be, it remains supremely indifferent to what the particular facts in our world actually are. Be they what they may, the Absolute will father them. Like the sick lion in Esop's fable, all footprints lead into his den, but *nulla vestigia retrorsum*. You can not redescend into the world of particulars by the Absolute's aid, or deduce any necessary consequences of detail, important for your life, from your idea of his nature. He gives you, indeed, the assurance that all is well with *Him*, and for his eternal way of thinking; but thereupon he leaves you to be finitely saved by your own temporal devices.

Far be it from me to deny the majesty of this conception, or its capacity to yield religious comfort to a most respectable class of minds. But from the human point of view, no one can pretend that it doesn't suffer from the faults of remoteness and abstractness. It is eminently a product of what I have ventured to call the rationalistic temper. It disdains empiricism's needs. It substitutes a pallid outline for the real world's richness. It is dapper; it is 'noble' in the bad sense, in the sense in which to be noble is to be inapt for humble service. In this real world of sweat and dirt, it seems to me that when a view of things is 'noble,' that ought to count as a presumption against its truth, and as a philosophic disqualification. The prince of darkness may be a gentleman, as we are told he is, but whatever the God of earth and Heaven is, He can surely be no gentleman. His menial services are needed in the dust of our human trials, even more than his dignity is needed in the empyrean.

Now pragmatism, devoted though she be to facts, has no such materialistic bias as ordinary empiricism labors under. Moreover, she has no objection whatever to the realizing of abstractions, so long as you get about with their aid among particulars, and they actually carry you somewhere. Interested in no conclusions but those which our minds and our experiences work out together, she has no *a priori* prejudices against theology. If theological ideas prove to have a working value for concrete life, they will be true, for pragmatism, in the sense of being *good for so much.* For how much *more* they are good, will depend on their relations to the other truths acknowledged.

What I said just now about the Absolute of transcendental idealism is a case in point. First, I called it majestic and said it yielded religious comfort to a class of minds, and then I accused it of remoteness and sterility. But so far as it affords such comfort, it surely is not sterile; it has that amount of cash value; it performs a concrete function. As a good pragmatist, I ought myself to call the Absolute true 'in so far forth,' then; and I unhesitatingly now do so.

But what does 'true in so far forth,' 'true for so much,' mean in this case? To answer, we need only apply the pragmatic method. What do believers in the Absolute mean by saying that their belief affords them comfort? They mean that since in the Absolute finite evil is 'overruled' already, we may, therefore, whenever we wish, treat the temporal as if it were potentially the eternal, be sure that we can trust its outcome, and without sin dismiss our fear and drop the worry of our finite responsibility. In short, they mean that we have a right ever and anon to take a moral holiday, to let the world wag in its own way, feeling that its issues are in better hands than ours and are none of our immediate business.

The universe is a system of which the individual members may relax their anxieties occasionally, in which the don't-care mood is also right for men, and moral holidays in order—that, if I mistake not, is part, at least, of what the Absolute is 'known as,' that is the great difference in our particular experiences which his being true makes for us, that is his cash value when he is pragmatically interpreted. Farther than that the ordinary lay-reader in philosophy who thinks favorably of absolute idealism does not venture to sharpen his conceptions. He can use the Absolute for so much, and so much is very precious. He is pained at hearing you speak incredulously of the Absolute, therefore, and disregards your criticisms because they deal with aspects of the conception that he does not follow.

If the Absolute means this, and means no more than this, who can possibly deny the truth of it? To deny it would be to insist that men should never relax, and that holidays are never in order.

I am well aware how odd it must seem to some of you to hear me say that an idea is 'true' so long as to believe it is profitable to our lives. That it is *good,* for as much as it profits, you will gladly admit. If what we do by its aid is good, the idea itself is good in so far forth, for we are the better for possessing it. But is it not a strange misuse of the word 'truth' to call ideas also 'true' for this reason?

To answer this difficulty fully is impossible at this stage of my account. You touch here upon the very central point of Messrs.

Schiller's, Dewey's and my own doctrine of truth, which I can not discuss with detail until my sixth lecture.[5] Let me now say only this, that truth is *one species of good,* and not, as is usually supposed, a category distinct from good, and coordinate with it. The true is the name of whatever proves itself to be *good in the way of belief,* and good, moreover, for definite practical reasons. Surely you must admit this, that if there were no value for life in true ideas, or if the knowledge of them were positively disadvantageous and false ideas the only useful ones, then the current notion that truth is divine and precious, and its pursuit a duty, would never have grown up or become a dogma. In a world like that, the duty would be to *shun* truth, rather. But in this world, just as certain foods are not only agreeable to our taste, but good for our teeth, our stomach and our tissues; so certain ideas are not only agreeable to think about, or agreeable as supporting other ideas that we are fond of, but they are also helpful in life's practical struggles. If there be any life that it is really better we should lead, and if there be any idea which, if believed in, would help us to lead that life, then it would be really *better for us* to believe in that idea—unless, indeed, belief in it incidentally clashed with other greater vital benefits.

'What it would be best that we should believe'! This sounds very like a definition of truth. It comes very near to saying 'what we *ought* to believe,' and in *that* definition of truth none of you would find any oddity. Ought we ever to believe what it is not *better for us* to believe? And can we then keep the notion of what is better for us, and what is true for us, permanently apart?

Pragmatism says no, and I fully agree with her. Probably you also agree, so far as the abstract statement goes, but with a suspicion that if we practically did believe everything that made for good in our own personal lives, we should be found indulging all kinds of foolish fancies about this world's affairs, and all kinds of sentimental superstitions about a world hereafter. Evidently something does happen, when you pass from the abstract to the concrete, that complicates the situation.

I said just now that what it is best that we should believe is true *unless the belief incidentally clashes with some other vital benefit.* Now in real life what vital benefits is any particular belief of ours most liable to clash with? What indeed except the vital benefits yielded by other beliefs when these prove incompatible with the first ones? In other words, the greatest enemy of any one of our truths may be *the rest of our truths.* Truths have once for all this desperate instinct of self-preservation and of desire to extinguish whatever contradicts them. Grant that the Absolute may be true in giving me a moral holiday. Nevertheless, as I conceive it (and I proceed to speak, now not as an

[5] That sixth lecture will soon appear in the *Journal of Philosophy, Psychology and Scientific Methods.*

abstract pragmatist, but merely in my own private person), it clashes with other truths of mine whose benefits I hate to give up on its account. It is associated with a kind of logic of which I am the enemy; it entangles me in metaphysical paradoxes that are inacceptable, etc., etc. But I have enough trouble in life already without the added trouble of carrying these intellectual inconsistencies, so I give up the Absolute. Personally, I just *take* my moral holidays; or else as a professional philosopher, I try to justify them by some other principle.

If I could restrict my notion of the Absolute to its bare holiday-giving value, it wouldn't clash with my other truths. But we can not easily thus restrict our hypotheses. They carry supernumerary features, and these it is that clash so. My disbelief in the Absolute means disbelief in those other supernumerary features.

You see by this what I meant when I called pragmatism a mediator and reconciler and said that she 'unstiffens' our theories.[6] She has in fact no prejudices whatever, no obstructive dogmas, no rigid canons of what shall count as proof. She is completely genial. She will entertain any hypothesis, she will consider any evidence. It follows that in the religious field she is at a great advantage both over positivistic empiricism, with its anti-theological bias, and over religious rationalism with its exclusive interest in the remote, the noble and the abstract in the way of conception.

In short, she widens the field of search for God. Rationalism sticks to logic and the empyrean. Empiricism sticks to the external senses. Pragmatism for her part is willing to take anything, to follow either logic or the senses, and to count the humblest and most personal experiences. She will count mystical experiences if they have practical consequences. She will take a God who lives in the very dirt of private fact—if that should seem a likely place to find him.

Her only test of probable truth is what works best in the way of leading us, what fits every part of life best and combines with the collectivity of experience, nothing being omitted. If theological ideas should do this, if the notion of God, in particular, should prove to do it, how could pragmatism possibly deny God's existence? She could see no meaning in treating as 'not true' a notion that was pragmatically so successful. You see how democratic she is. Her manners are as various and flexible, her resources as rich and endless, and her conclusions as obedient and malleable as those of mother nature.

[6] I get this word from Papini (Leonardo, Aprile, 1905).

CIVOLOGY—A SUGGESTION

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SO far civilization—Johnson 'abominated' the word and suggested 'civility' instead—has been considered philosophically, described historically, viewed esthetically and computed statistically. I say 'so far,' and I may add 'so good,' for by these disciplines the phenomena in question have been arrayed under their vicarious aspects with illuminating, impressive, interesting and significant results. Hence we have systems, narratives, tales and tables, all of which are well enough in their respective ways. As a whole, however—if one can consider them collectively—these systems, narratives, tales and tables lack continuity. Coordination is required, so, it seems to me, civilization should be subjected to scientific research. Ours is the age of science, we affirm; certainly each century has contributed its quota. To the credit of the nineteenth belongs biology, which has succeeded in coordinating the phenomena of life; it is the task of the twentieth, I take it, to coordinate the phenomena of civilization and afford us the science of, *Civology,* shall I say?

But why, you ask, is a new science necessary? Civilization is the work of man and anthropology, the science of man, is already established. Beavers build dams, but there's not one science of beavers and another of their dams, why, then, one science of man and another of his works? If men established civilizations by instinct, as beavers build dams, and the same sorts of civilizations from generation to generation, with only such changes as are effected through selection, there would be no necessity of a separate science, but such is not the case. Civilization is not instinctive and conservative, it is purposive and progressive. So there is something in the distinction Spencer sought to establish between organic and super-organic phenomena. Man himself is an organic phenomenon, his works, however, are super-organic—to be sure, they proceed, as Spencer said, by insensible steps out of the organic, even as organic phenomena proceed by insensible steps out of the inorganic, still for this very reason they are *super*-organic. Since such is the case, manifestly man and his works can not be included within one science; there must be two sciences, one of man, and another of his works. It is of no avail—in fact it only mixes matters the more—to divide anthropology into two parts: physical anthropology, which purports to deal with man himself, and cultural anthropology.

which sets out to consider his works. Inasmuch as man is an organic phenomenon, anthropology, the science of man—like botany, the science of plants, and zoology, the science of animals—is properly speaking a branch of biology, the general science of all organic phenomena. Call this physical anthropology if you prefer—though the adjective seems to me superfluous—but pause and consider before you speak of cultural anthropology. The adjective in this case is incongruous; cultural includes man's works, which are confessedly super-organic. Now there may be no principles capable of coordinating these super-organic phenomena—if so there can be no such thing as a science of civilization—but simply because these principles are still unknown, or unknowable, if you like, is no reason why other known principles should be accepted to serve their stead. You can not coordinate organic phenomena under inorganic categories, why should you expect to coordinate super-organic phenomena under organic categories? But this is precisely what is proposed by the incongruous combination: *cultural anthropology*—the science itself is organic, its subject-matter is super-organic.

Congruity requires that the new science shall be super-organic to correspond with its subject-matter. But there is such a science, you say, sociology, which claims to be *the* science of super-organic phenomena. If 'social' and 'super-organic' were synonymous, as Spencer supposed, the claim would be justified, but they're not, and no amount of argument or assumption can make them so. To go no further for the moment, it is evident enough man's works are individual and familial as well as social; then too, from another point of view, some of man's works are economic, others esthetic, and so on, all of which are included within the broader concept 'civilization,' but not necessarily within the narrower concept 'society.' Thus though sociology is, logically at least, *a* science of super-organic phenomena, it is certainly not *the* science of super-organic phenomena, since it does not, and can not be made to coordinate the subject-matter in question. All organic phenomena are coordinated under the general science of biology, perhaps some day all super-organic phenomena will be coordinated under the general science of civology. If so, sociology will constitute one of the subsidiary sciences of civology, even as morphology constitutes one of the subsidiary sciences of biology. Till then the so-called science should be classed among the above-mentioned 'systems.' Even as such —if I may add a word by way of criticism—it is not a striking success—to quote from a recent writer: "In regard to the fundamental principles of sociology, the confusion is hopeless. The student will search in vain in the systematic treatises on sociology for any definite body of established doctrine which he can accept as the ground principles of the science. He finds only an unmanageable mass of conflicting theories and opinions. Each treatise contains an exposition of what the author is pleased to label the 'Principles of Sociology.' But the 'Principles' are not the same in any two treatises; and by no process of analysis and synthesis can they be brought into harmony. They are fundamentally contradictory. It is impossible, I believe, to discover a single alleged ground-principle of sociology that has commanded general assent."[1] If so, well may Gabriel Tarde advise his fellow sociologists: "Instead of discoursing upon the merits of this infant sociology—which men have had the art to baptize before its birth—let us succeed, if possible, in bringing it forth."

Setting aside cultural anthropology as inadequate and sociology as insufficient, I revert to the necessity of a new science. As to its name, it is premature, perhaps, to baptize this infant also before its birth, but I may at least be allowed to suggest *Civology*. I do so for consistency's sake; life is organic, civilization is super-organic, the organic science of life is called biology, the super-organic science of civilization should be called civology. I assume, you see, that civilization and super-organic are synonymous, and rightly, I think; certainly all civil phenomena are super-organic, the only question is: are all super-organic phenomena civil? They are essentially so, I should say, and, in any event, civilization is such a flexible term it may very well, far better, in fact, than any other, be extended so as to include all the phenomena in question. But enough of the name, now for the substance of the new science. Its subject-matter is super-organic; so much is established. The next step is to formulate fundamental principles capable of coordinating super-organic phenomena—an exceedingly long step. Indeed it is, so long, I fear I shall be obliged to jump at conclusions. Fortunately the path is well paved to this point, and beyond the general direction of advance is defined. So far science exhibits an orderly processus of phenomena, with the result that organic phenomena have been shown to proceed by insensible steps out of the inorganic. I assume simply that such consistency continues to the end, with the result that super-organic phenomena proceed by insensible steps out of the organic. If so, civology stands in the same relation to biology that biology stands to physics and chemistry. The fundamental principles of biology are subsequent to and consistent with the fundamental principles of its antecedent sciences, physics and chemistry; accordingly, the fundamental principles of civology should be subsequent to and consistent with the fundamental principles of its antecedent science, biology. Before taking the step—or making the leap, if you like—it will be best, then, to go back a bit, and, passing the line of organic evolution in review, run over the fundamental principles of biology.

Organic evolution is characterized by countless variations, according to which the manifold forms of life can be classified under more

[1] F. Spencer Baldwin, 'Sociology,' Popular Science Monthly, LV., p. 817.

or less definite categories—kingdoms, sub-kingdoms, classes, orders, families, genera, species and varieties, with many intermediate divisions—and arranged in an ascending series culminating, as we view it, in man. The extrinsic cause, or perhaps I should say the condition, of these variations is *environment*. The intrinsic cause is the physiological principle of *variability*, or *mutability*, by which biologists mean the susceptibility to modification inherent in organic life, 'that plasticity or modifiability of any organism in virtue of which an animal or a plant may change in form, structure, function, size, color, or other character, lose some character or acquire another, and thus deviate from its parent form.' This tendency of all organisms to become unlike their parents is, as I say, in first instance an intrinsic quality, and, like other natural attributes, transmissible from generation to generation. But though originally instrinsic, variability is only called into play by extrinsic conditions. As a result, organic variations are the outcome of an interaction between intrinsic and extrinsic factors, variability and environment. Looking along the line of organic evolution, the general tendency appears to be toward the preservation of the more useful and the extinction of the less useful or useless characters. This is due, in first instance, to adaptation, and then to the fact that selection in one form or another has been operative all along the line, eliminating the unfit or ill-adapted from the struggle for existence and allowing only the fittest or best adapted to survive. *Selection* acts accordingly as the regulative factor of organic evolution—so in last analysis variations become "the accomplishment of that which variability permits, environment requires, and selection directs." To be noted also is the fact that variability, or the tendency to vary under environmental conditions, is counteracted to a considerable extent by *heredity*, or the tendency to breed true, the former being the progressive, the latter the conservative, principle of organic evolution.

Man himself is an animal, the final product, apparently, of organic evolution. Classified biologically he belongs to the sub-kingdom: *Vertebrata*, class: *Mammalia*, order: *Primates*, sub-order: *Anthropoidea*, family: *Hominidae*, which family constitutes one genus and a single species. In the course of its evolution this single species has, however, become further differentiated into at least four sub-species, which constitute the great races of man—and these in turn into a great number of ethnic varieties. Arranged in an ascending series, we rank the Negro, or Black race, lowest; next the American, or Red race; then the Mongolic, or Yellow race, and finally the Caucasic, or White race. Within this last we take the Anglo-Saxons to represent the highest ethnic type—though this is more or less arbitrary, depending upon the point of view. But whatever the order of arrangement, there can be no doubt of this: these several races and numerous varieties of mankind represent so many organic variations of the human species, effected through the interaction of variability and environment, and established by adaptation and selection. Now each of these races and every variety of the human species has contributed something to the sum total of civilization. So it seems, in man's case, the line of organic evolution is succeeded and supplemented by a line of super-organic development. And as the line of organic evolution is characterized by countless variations culminating in the several races and numerous varieties of man, even so is the line of super-organic development characterized by successive states of civilization, established by the several races and numerous varieties of man. These states of civilization likewise can be classified according to their complexity and arranged in an ascending series, culminating, if you like, in the existing civilization of the Anglo-Saxons—though this again is a matter of opinion, or prejudice perhaps. But whatever the order of their arrangement, of this I am quite convinced: these states of civilization connote in last analysis so many *systems of utilization.* My concept of the subject may seem somewhat restricted, but I assure you it will expand as we proceed, meanwhile I ask you only to accept the connotation provisionally, as a possible point of departure.

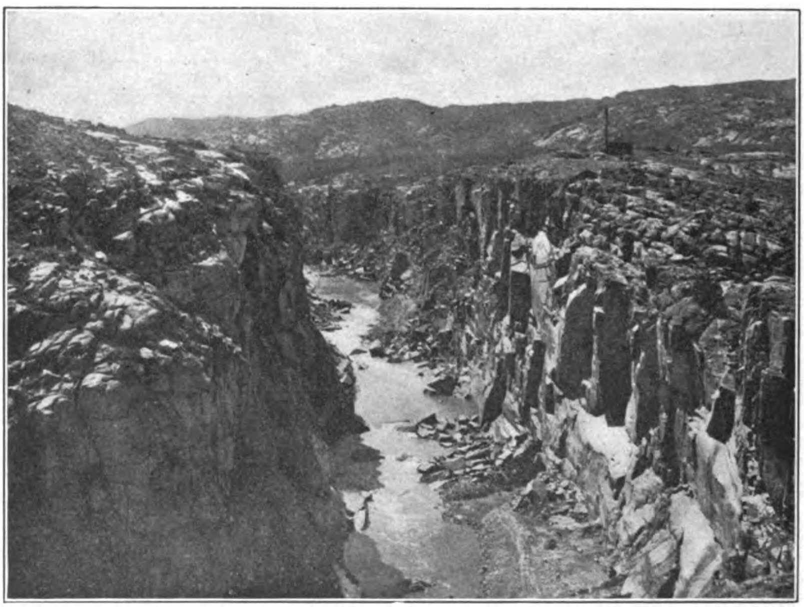
This at least is obvious: in order to live and move and have their being—to say nothing of meliorating their material condition—human beings are obliged to utilize the resources at their disposal. The manners in which and the means and methods whereby they do so are determined by the circumstances—physical, social and historical—within which they strive. *Circumstance* constitutes, accordingly, the extrinsic cause or condition of utilization. The intrinsic cause in this case is the psychological principle of *utility,* which is the quality of satisfying wants—an elusive and very variable quality, to be sure, none the less appreciable for all that. All men seek to satisfy their wants, therefore all men may be said to strive after utility. The quality in question supplies, as it were, the stimulus, the incentive, or better perhaps, the motive that makes for utilization. So I should say utility constitutes the progressive principle of super-organic development, even as variability constitutes the progressive principle of organic evolution. To acquire such utility and so satisfy their wants, men, as I have said, must utilize the resources at their disposal, in the manner and by the means and methods most in accordance with their circumstances. So it appears super-organic systems of utilization are, like organic variations, the outcome of an interaction between intrinsic and extrinsic factors, utility and circumstance in this case. Looking along the line of super-organic development, the general tendency appears to be toward the augmentation of utility accompanied by increasing complexity in the process of utilization. This is due to the expansion of human wants, the satisfaction of one usually causing another to emerge in the mind, and so on indefinitely. Circumstances conscribe and restrict such expansion always and everywhere; so, not being able to satisfy all their wants at once, men are compelled to choose between the satisfaction of one and the satisfaction of another. Such choice is effected through evaluation, which comes in last analysis to this: in every set of circumstances each man asks himself, 'to the satisfaction of which of my many wants do I attach the most immediate importance? which, in a word, is most worth while?' and having decided, proceeds to utilize his resources accordingly. The same is true in a more general way of peoples and races; as a result of a long series of evaluations, groups as well as individuals establish their standards in accordance with their physical, social and historical circumstances. So I should say: *evaluation* constitutes the regulative factor of super-organic development. If so, utilization becomes in last analysis the accomplishment of that which utility suggests, circumstances allow and evaluation controls. A word in conclusion: because of the expansion of human wants, utility constitutes the progressive principle of super-organic development, but utility is counteracted to a considerable extent by imitation, the disposition to accept traditionally established standards and utilize in accordance with custom and convention instead of circumstance—*imitation* constitutes accordingly the conservative principle of super-organic development.

Before stepping over from the formulated organic into the unformulated super-organic, in order to indicate the direction and measure the distance I said: the fundamental principles of civology should be subsequent to and consistent with the fundamental principles of its antecedent science, biology. Having taken the step—or made the leap, if you like—let us look about us and see where we have landed. In the first place, are the super-organic principles suggested consistent with the organic principles already established? They seem to me so —I appeal to comparison. Biology has succeeded in coordinating the phenomena of life; the task I set civology was to coordinate the phenomena of civilization. The phenomena of life are organic, the phenomena of civilization are super-organic. The former, that is the phenomena of life, present themselves to science as variations; the latter, that is the phenomena of civilization, should, I say, present themselves to science as systems of utilization. Organic variations are conceived of by biology as the accomplishment of that which variability permits, environment requires, and selection directs; so, it seems to me, super-organic systems of utilization should be conceived of by civology as the accomplishment of that which utility suggests, circumstance allows and evaluation controls. The parallelism between the two processes is apparent: Both proceed from intrinsic principles which are progressive in character—the organic process from the principle of variability, the super-organic process from the principle of utility. In each case the progressive action of these intrinsic principles is conscribed and restricted by extrinsic conditions—variability by environmental conditions, utility by circumstantial conditions. In each case also the interaction of intrinsic principles and extrinsic conditions is directed and controlled by factors which are neither intrinsic nor extrinsic, but rather intermediate in character—the interaction of variability and environment by selection, the interaction of utility and circumstance by evaluation. Finally, both processes are arrested and established to some extent by the influence of other intrinsic principles that are conservative in character, the organic process by heredity, the super-organic process by imitation. But enough of this, a parallelism pushed too far comes dangerously near an analogy. In another paper I shall endeavor to show in what sense the suggested principles of super-organic development are subsequent to the known principles of organic evolution.

THE RECLAMATION OF THE NORTH PLATTE VALLEY

By W. S. COULTER,
ASSISTANT ENGINEER, U. S. R. S.

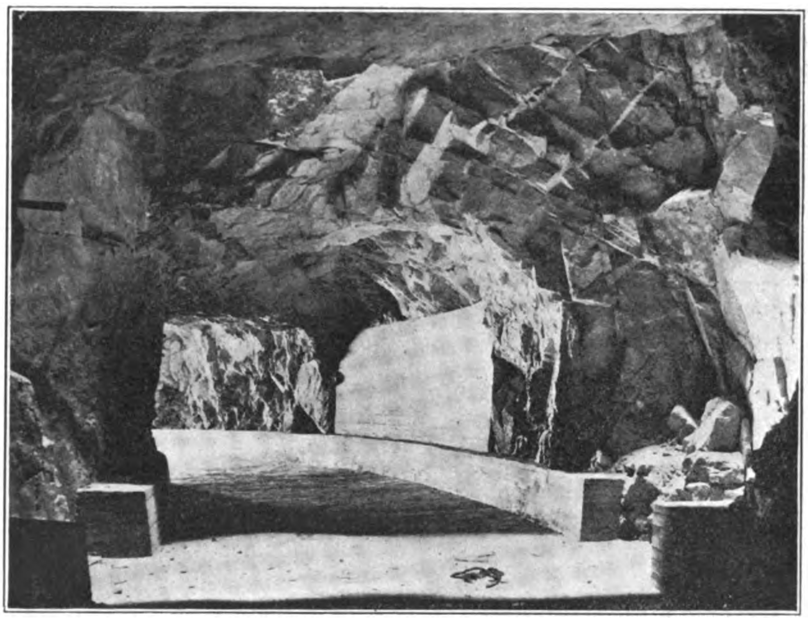
THE North Platte River rises in the semi-arid region of the North Park Mountains in Colorado and flows into Wyoming, its course through the latter state describing a rough quadrant of about one hundred and fifty miles radius, having for its center the southeast corner of the state. Eighty miles from the state line it turns to the southeast and so continues to its junction with the South Platte in central Nebraska. The route through the last two states lies almost wholly



PATHFINDER CANYON ON THE NORTH PLATTE RIVER. LOCATION OF DAM SITE.

within the arid region and drains, in Wyoming, a mountainous country where the snow lingers long into the early summer. During the winter and spring the snowfall upon the peaks is considerable, and when the white mantle begins to dissolve under the increasing heat of the summer sun, the rivers are gorged with the flood waters. The North Platte, which trickles along the center of a broad gravel bed throughout the summer, a pigmy sporting the habiliments of a giant, assumes monstrous proportions at this season, swelling from a few hundred second-feet in August to as much as twenty thousand in May, and the uncouth pile bridges that, stretched meaninglessly for hundreds of feet over a stream confined within the limits of a single bent, find their shore abutments awash with the mighty swirl.

Were there no mountains to gather and release the frozen supply, the North Platte might always remain a comparatively small stream of equalized flow, as the precipitation is slight on these brown, arid plains, and the soil absorbs moisture with avidity. Because of this lack of moisture, the soil, though rich in plant constituents, is not susceptible to cultivation, excepting where its position relative to the river margin is such that irrigation may be practised. Many thousands of acres of land, favorably situated, lie along the banks of the North



INTERIOR OF PATHFINDER DIVERSION TUNNEL.

Platte, especially in the extreme easterly part of Wyoming and in Nebraska, and the settlers have utilized the river waters individually and through cooperative associations for the past two decades.

The strength of a heavy chain, when measured by the resistance of its weakest link, may be very small. The total annual flow of the North Platte is large, but the maximum discharge occurs in the spring and early summer at, or slightly before, the beginning of the irrigating season. Throughout the period of irrigation the flow diminishes until, in the sweltering days of August, the torrent of May is reduced to the dimensions of a respectable creek. The amount of land that may be successfully irrigated by waters diverted directly from the river must

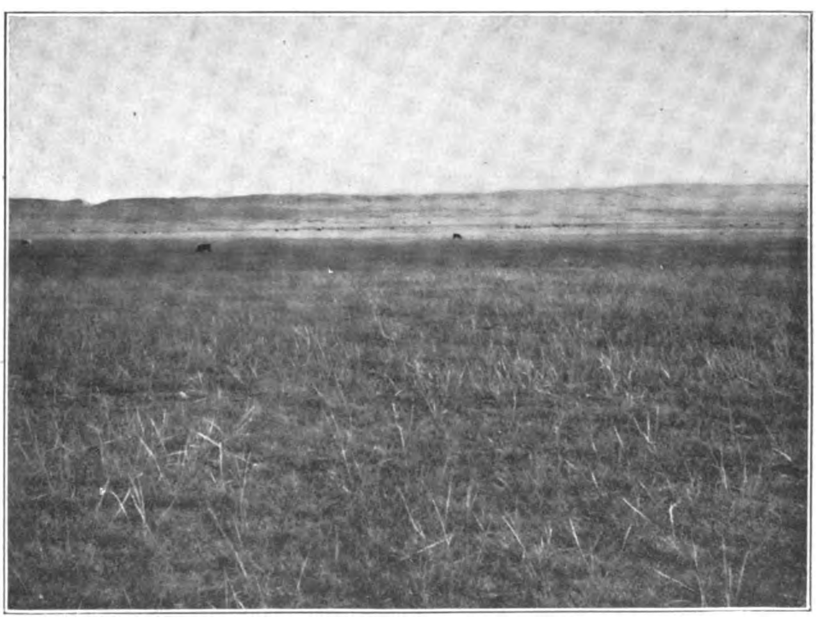
FIFTY-FOOT CUT ON THE INTERSTATE CANAL.

be measured by this minimum flow during the irrigating season, and unless some method be found whereby the floods of spring may be utilized during the summer months, only a limited area of the fertile lands along the river can be reclaimed.

The solution of the problem obviously lies in the construction of a storage reservoir having a capacity sufficient to retain the flood waters of spring, releasing them during the summer months as needed. The construction of such a storage reservoir and dam, with the auxiliary diversion dams, headworks and canals, and the adjustment of rights of way, water rights and other perplexing legal matters, is a task requiring large sums of money and efficient organization—sums so vast and organization so perfect that no combination of settlers in a new, sparsely settled country could hope to achieve it. Private capital may be advanced by outside parties if a private monopoly of the water-supply be granted, but in such a case the water users must be always resisting the encroachments that follow the private ownership of natural monopolies. The capital may be advanced by outside parties and the works constructed under their supervision, not for the purpose of obtaining a private monopoly, but to turn the whole over to an organization of the water users when they shall have refunded the cost of installation plus a reasonable return at current rates of interest. There is but one party powerful enough and philanthropic enough to do this, and, if the arid regions are to be equitably reclaimed without the creation of powerful private monopolies, it is to the national government that we must look for assistance. The disinterested position and financial sufficiency of the government and the power it possesses to coordinate those portions of projects lying in different states render it peculiarly competent to undertake this work.

As a result of thorough preliminary investigations, a reservoir site for the storage of the waters of the North Platte was located near the mouth of the Sweetwater River in central Wyoming. The site is a natural basin, the enclosure having but one outlet, through which the river escapes by a granite gorge extending for a quarter of a mile through the hills. This canyon is approximately two hundred feet deep and one hundred feet wide, and presents an ideal site for a dam by which to convert the basin above into an immense storage reservoir, while the surrounding hills of fine-grained granite contain the materials for construction. The one unfavorable feature is the location of the dam site with reference to the railroads, the nearest point being forty-five miles distant. The thousands of barrels of cement and the contractor's heavy plant must be transported over this long stretch of earth road, materially increasing the cost of construction. Yet the natural fitness of the site is such that the cost of the dam and appurtenances relative to the body of water impounded is but one dollar per acre-foot stored.

The dam to be constructed at this point will be of the arch type, ninety-four feet thick at the base, two hundred and ten feet high and about two hundred and thirty feet long at the crest. The preliminary



VIEW NEAR BRIDGEPORT, NEBRASKA, SHOWING TYPICAL AREA OF LAND IT IS PROPOSED TO IRRIGATE.

estimate of stone masonry is fifty-three thousand cubic yards and of concrete one thousand cubic yards, together calling for forty thousand barrels of cement. The contract for the dam, exclusive of a cut-off and dike, was awarded September 1, 1905, for $482,000, the government to furnish the cement at the nearest railroad point. During the summer a tunnel was constructed through the canyon walls, the upper portal located above and the lower portal below the dam site, for the purpose of diverting the waters of the river during the construction of the dam and to be used later for the passage of stored water.

The annual run-off from the Pathfinder watershed is about 1,500,000 acre-feet, and the capacity of the proposed reservoir is 1,025,000 acre-feet, being sufficient to retain about two thirds of the entire discharge of the North Platte at this point for one year. A conservative estimate of the area it is possible to irrigate under favorable circumstances, with the amount of water to be stored in the Pathfinder Reservoir, lies between 300,000 and 400,000 acres. During the irrigating season it is proposed to allow the surplus water stored in the reservoir to escape into the river bed as needed, augmenting the normal flow, to be intercepted by diversion dams and turned into the headworks of the canals that are to conduct it to the lands it is intended to irrigate.

The irrigable lands lying below the reservoir have been surveyed, and wherever it seemed that any considerable area could be reclaimed for a reasonable expenditure, a preliminary location of canals and study of the necessary structures involved were made and the probable cost estimated. Some of the schemes were rejected because of excessive cost and others are in abeyance, but the Interstate Canal has been pronounced practicable by a consulting board of engineers and is now in process of construction. This canal heads at a point about eight miles above old Fort Laramie in Wyoming and follows the northerly side of the valley for one hundred and fifty miles to a point near Bridgeport, Nebraska. The land underlying this canal in the extreme eastern part of Wyoming and in Nebraska is of excellent quality, requiring but the application of sufficient water to yield bountiful returns. No alkali demands the construction of expensive underdrains on these lands, and, with the lands south of the river and those lying higher up the valley in Wyoming, there is an area sufficient to exhaust even the resources of the huge Pathfinder Reservoir. A conservative estimate of the probable area underlying the Interstate Canal, and to receive its service, is something more than 100,000 acres. The canal is designed to carry about 1,400 second-feet of water at the headworks. The first forty-five miles was divided into ten contracts, which were awarded during the months of June and July, 1905, and construction has been in progress throughout the summer, with the outlook bright for water in time for the irrigating season of 1906. In November the second fifty miles was awarded. There are no tunnels on the Interstate Canal and no expensive construction, the alignment following the outlying gravel knolls along the bluff that borders the valley, occasionally intercepting these or encountering short stretches of Brule clay. In the quality and extent of irrigable lands and their favorable juxtaposition to economical canal alignments, the North Platte project is favored in its distribution system as well as in storage facilities.

The average rainfall over the irrigated area will probably not exceed thirteen inches per annum. The mean temperature is 45°, the maximum 98°, and the minimum — 20° Fahrenheit, and the length of the growing season is sufficient to mature most of the crops raised in this latitude, including corn. The principal crop at present grown is alfalfa, with some corn, oats, wheat, sugar beets and potatoes. The principal supply market is Omaha, but Denver, Kansas City and St. Joseph are contributory. The greater part of the produce will be marketed in the west, unless demand and supply shall be sufficiently disturbed to unsettle their present balance.

Taking eighty acres as a unit and assuming the total area to be irrigated under the North Platte project as 300,000 acres, there will be 3,750 farms. Assuming that the average family consists of five persons, we have 18,750 persons occupying these lands.

Adding to these the merchants, blacksmiths, carpenters, doctors, clergymen and others, with their families, for whom this population will provide patronage, the total becomes approximately thirty thousand persons, exclusive of a probable additional population employed in canning factories. This community will be based upon good homes on the land, free from tenantry and collectively participating in the natural opportunity upon which each irrigator depends. The population at present inhabiting these lands is small, numbering not more than a couple of thousand persons.

This work of the Reclamation Service with its promise of partial relief from the urban congestion that threatens the nation is carried forward by moneys received from the sale of public lands. These moneys are restored to the government by the water users and all possibility of initial tenantry is prevented by the stipulation that tracts exceeding a certain size, between forty and one hundred and sixty acres, must be subdivided and sold to persons who will use them to obtain a livelihood before water will be placed on the land.

It has been well said that the safeguard of a nation is a large population of working farmers, owning the land they use, and as a means for the partial accomplishment of this desirable condition, the work of the Reclamation Service deserves commendation.

SHORTER ARTICLES.

A VOCABULARY TEST

PROFESSOR KIRKPATRICK'S article in a recent number of the POPULAR SCIENCE MONTHLY leads me to present the results of an investigation on practically the same lines, extending over several years when I was engaged in teaching college students to read German. I used a dictionary test, a little different in detail, but practically the same as Professor Kirkpatrick's, to find the number of German words which could be defined by students when they entered the second year's work in the subject in college. Some of them had had one year's college instruction, and others were admitted on examination.

I found that the vocabulary of those who could pass such an examination was never less than 2,000 words, and went from that up to 5,000. The mark received on the examination was in close relation to the extent of the vocabulary. Those who had more than 5,000 words were generally fit to go into a higher course.

The test was repeated at the end of the year. The result then was from 5,000 to 12,000 words. The marks on the final examination of the second year's course were also in close relation to the extent of the vocabulary. I tried this with classes for several years, getting sufficiently uniform results to prove conclusively to my mind that these were the normal figures.

I was then interested to extend the investigation to English, and had several classes make the same experiment for their own language, but with the very important feature that I used an unabridged dictionary, containing over 100,000 words, instead of one containing only 28,000. I found that most of the college sophomores reported from 50,000 to 60,000 words. Of course, if they had had only 28,000 to select from, it would not be surprising if they had reported only 20,000; and I think that Professor Kirkpatrick made a mistake in using so small a book. I found that students who had not studied Greek regularly reported from 10,000 to 15,000 words less than those who had.

I also experimented with a number of people who had never been to college, but, with an ordinary common school education, were regular readers of books and periodicals. These reported generally from 25,000 to 35,000 words, though some of them went higher, even as high as the lower figures of the college students.

I then took a few cases of the working vocabulary in foreign languages of those really proficient in them, chiefly among modern language teachers. The results are probably fairly typified by my own case, which could, no doubt, be matched by almost any one who has made a life study of different languages. I found that my English vocabulary was about 65,000 words; German (counting all compounds given in the dictionary), 58,000; Danish (largely the same roots as German), 52,000; French, 30,000; Italian, 22,000; Latin, 18,000; Spanish, 16,000; Greek, 13,000, and Old Norse, 11,000.

I should guess that these figures, which are for languages belonging to only two general families, could be reduced to 20,000 or 30,000 actual roots, or perhaps even less; but to verify such a guess would require an investigation with a system of slips, for which I probably shall never have time. I leave the interpretation of these facts to the reader, who can be assured that they are facts.

E. H. BABBITT.

THE PROGRESS OF SCIENCE

A NATIONAL DEPARTMENT OF PUBLIC HEALTH

THE physicians of the country and the American Medical Association have long advocated the establishment of a department of public health as part of the national government, and they now have the cooperation of an influential committee of one hundred, which had its origin at the Ithaca meeting of the American Association for the Advancement of Science. Professor Norton, of Yale University, there read a paper on the economic advisability of a national department of health in which he pointed out the waste due to preventable death and disease. Apart from the incalculable misery, the saving in money that could be effected in this country was placed at from two to four billion dollars a year. Professor Fisher, of Yale University, who was chairman of the section of economic and social science of the association, is chairman of the committee of one hundred, which includes many of those most active in all good works, such as Presidents Eliot, Hadley, Angell and Gilman, Drs. Welch, Bryant and Biggs, the surgeon generals of the army and navy, Messrs. Felix Adler and Lyman Abbott, and others of equal influence. It may not be easy for such a committee to agree on a definite plan, but their recommendations should carry great weight with the president and the congress.

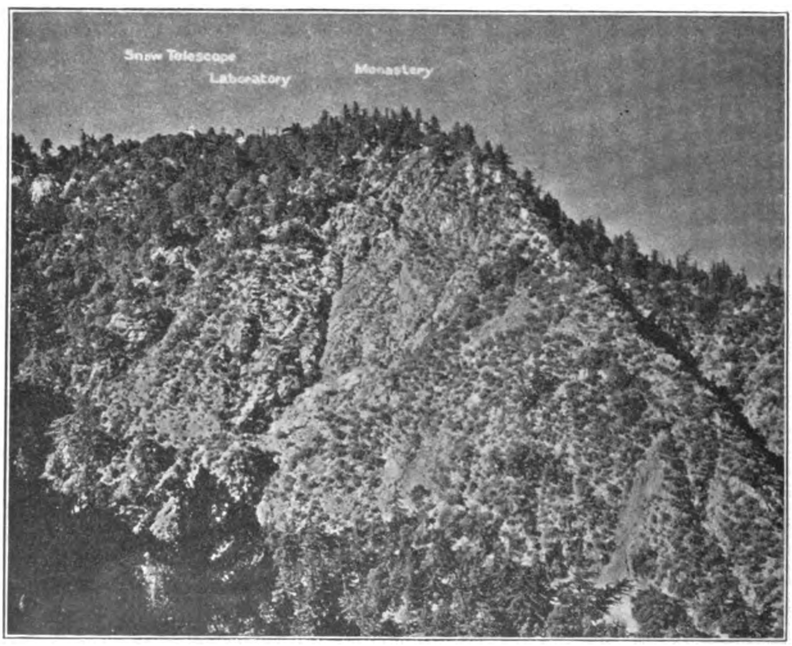
The first question appears to be as to whether a national department of health with a cabinet officer should be advocated or whether only a bureau should be recommended for the present. It is a curious fact that our cabinet is smaller and less democratic than that of any other great nation. We alone have no ministry of education. Certainly the fusion of the war and navy departments with one secretary only and the establishment of three new departments and cabinet ministers —one of science, one of education and one of health—would more nearly represent what should be the proper functions of government than our present system. But tnis is a question for the future. A less radical reorganization, and one within the range of possibility, should sensible people unite to advocate it, would be the transference of pensions from the Department of the Interior to the army and navy, where they belong, leaving the Department of the Interior free to become essentially a department of science, education and health, whose representative in the cabinet should be a man such as President Eliot or Dr. Welch. Apart from pensions and the land office (which latter might be transferred to the Department of Agriculture or of Commerce and Labor), the Department of the Interior now consists of the Bureau of Education and of Indian Affairs, the Patent Office and the Geological Survey. If bureaus of science, of public health and of fine arts were added, the Department of the Interior would become a 'Cultusministerium.' It appears likely that the most that can be accomplished by the committee of one hundred and the American Medical Association at present would be the establishment of a Bureau of Health coordinate with the Bureau of Education under the Department of the Interior. The function of these two bureaus for the present would be mainly that of coordination and the collection and diffusion of information, but they would be free to develop as rapidly as the general sentiment of the country permitted.

It is not evident that all the work of the government for science or for public health should be concentrated in one department or bureau. Under existing conditions it is probably better that they should be found in each department. Thus the Agricultural Department is substantially a Department of Agricultural Science, and the Navy Department should become a Department of Naval Science, the Treasury Department a Department of Economic Science, etc. It is a distinct advantage that work on behalf of health should now be done under at least six of the nine departments of the federal government. What we need is an increase in amount, range and scientific productivity of the work done under each department, and a new bureau which can coordinate this work and cooperate in its extension.

THE RESEARCH DEPARTMENTS OF THE CARNEGIE INSTITUTION

Appended to the report of the president of the Carnegie Institution for 1906 are accounts of the scientific work carried forward under the auspices of the institution during the year. In addition to some forty minor grants, amounting in all to nearly $100,000, there were eleven departments, for the support of which over $450,000 was appropriated.

The largest appropriation last year was for the department of solar physics under the direction of Professor George E. Hale. Further progress has been made in equipping the observatory on Mt. Wilson, and a road has been built to the summit. Research has been carried forward in various direc-



Mt. Wilson, from Mt. Hamilton, the Seat of the Solar Observatory of the Carnegie Institution.

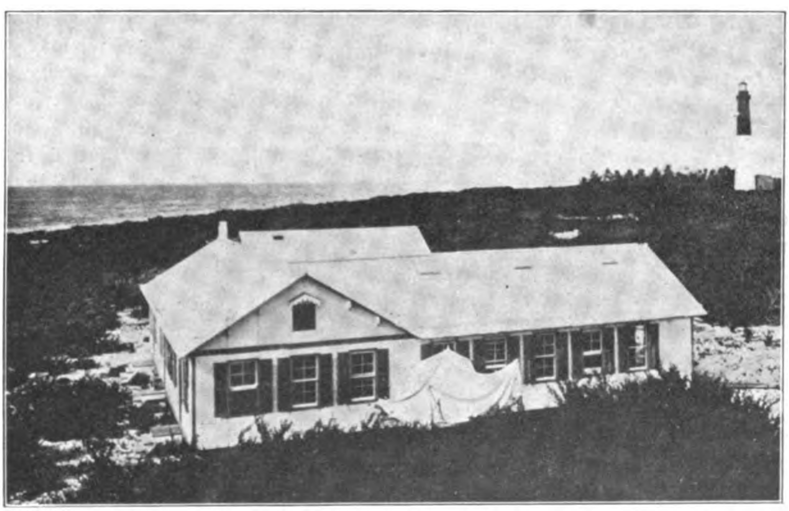
tions, including photography of the sun and of the spectra of sun-spots. Mr. John D. Hooker, of Los Angeles, has made a gift of $45,000 for a mirror of one-hundred-inch aperture for a great reflecting telescope. The largest new project planned was also for astronomy and consists of an appropriation of $200,000 extending over a decade for a catalogue giving the precise positions of the brighter stars. This involves the establishment of a meridian observatory in the southern hemisphere. The execution of the work has been entrusted to Professor Lewis Boss, director of the Dudley Observatory at Albany.

Next to astronomy, geophysics is most liberally supported by the institution. A special laboratory for geophysical research is being erected in Washington at a cost of $150,000. Dr. A. L. Day, who will have charge of the department, succeeded last year in producing quartz glass, which is of value owing to its high melting point and low rate of expansion under temperature changes. Work in terrestrial magnetism under Dr. L. A. Bauer, who has resigned his position in the U. S. Coast and Geodetic Survey, is supported by an appropriation of $54,000. The yacht *Galilee* made last year two voyages in the Pacific, traversing some 26,000 miles.

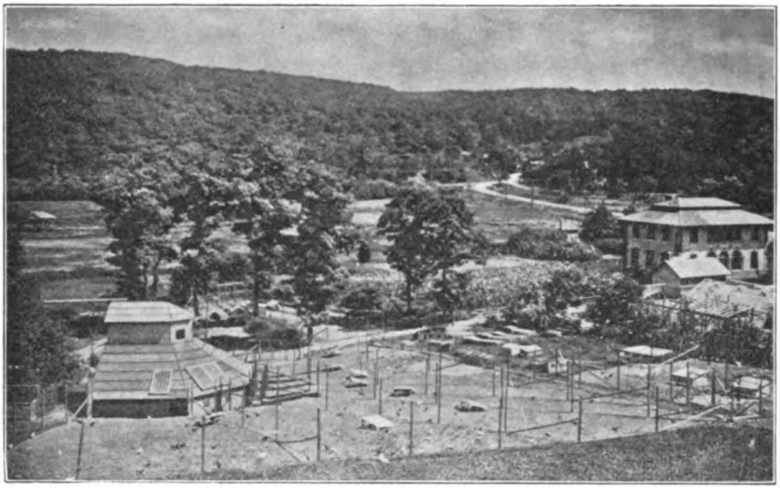
A new department, established last year, was that of botanical research, under the direction of Dr. D. T. MacDougal, whose headquarters are the Desert Laboratory at Tucson, Ariz. The flora of the arid regions has been studied, including the vegetation of the Salton Basin, while Dr. MacDougal has continued his experiments at the New York Botanical Garden on discontinuous variation in plants. One of the larger projects is also the work in horticulture of Mr. Luther Burbank.

Two departments are devoted to biology. Work in experimental evolution is conducted under the direction of Professor Charles B. Davenport at Cold Spring Harbor, where land has been secured and a laboratory erected. The other is the department of marine biology conducted under Dr. A. G. Mayer at the Dry Tortugas, Florida. A temporary laboratory has been built there.

Work in nutrition has been carried on by Professor F. G. Benedict, Professor R. S. Chittenden and Professor F. B. Osborne. This is regarded as one



View of the Main Laboratory at the Tortugas Station for Marine Biology of the Carnegie Institution.



VIEW ACROSS COLD SPRING VALLEY LOOKING SOUTHEASTWARD, SHOWING PART OF THE GROUNDS OF THE STATION FOR EXPERIMENTAL EVOLUTION OF THE CARNEGIE INSTITUTION. Main building at the extreme right, potting house and propagating house in front, and vivarium, under construction, in front of and to left of latter. To the left (north) of the main building is seen part of the east experimental garden. Near the extreme left is the brooder house, from which radiate eight poultry runs, seen in the middle foreground.

of the major projects, and it is planned to continue it on a more extensive scale, funds having been appropriated for the erection of a laboratory, which will be placed under the direction of Professor Benedict. It is stated that the laboratory will be built where pathological cases can be secured for investigation, and it is now reported that it will be placed in Boston.

The two remaining departments are economics and sociology and historical research. The former, under the direction of President Carroll D. Wright, of Clark College, is preparing an economic history of the country with the assistance of more than a hundred collaborators. As head of the department of historical research, Professor J. F. Jameson has succeeded Professor A. C. McLaughlin. The department aims to be a clearing-house for the historical profession, and is engaged in various miscellaneous activities, thus differing somewhat from the other departments.

It will be of great importance for science to learn whether research work can be conducted more economically and efficiently in institutions of this character than when combined with educational work, as at our universities, or with economic work, as under the government. More than half the income of the institution is appropriated for work in astronomy and geophysics, in which subjects the president is especially competent, but it may be doubted whether it is an advantage for institutions in California, Arizona, Florida, New York, Massachusetts and South America to be conducted from Washington. It would probably be better if the laboratories were built and endowed, and their future development entrusted to local control.

THE SAGE FOUNDATION

ANOTHER great foundation on the lines of those established by Mr. Carnegie and Mr. Rockefeller is now announced. Mrs. Russell Sage has offered to give ten million dollars to a board to be incorporated by the New York legislature for a foundation the object of which shall be "the improvement of social and living conditions in the United States. The means to that end will include research, publication, education, the establishment and maintenance of charitable and beneficial activities, agencies and institutions, and the aid of any such activities, agencies and institutions already established." The original trustees are: Robert W. De Forest, Cleveland H. Dodge, Daniel C. Gilman, John M. Glenn, Miss Helen Gould, Mrs. William B. Rice, Miss Louisa L. Schuyler and Mrs. Sage.

This foundation represents a movement that is likely to become dominant in the twentieth century. The future of the race depends largely upon whether what Dr. Galton has named 'eugenics' can be made a science and applied for our welfare. We trust that the income will not be used mainly to establish or assist charitable institutions, but rather for the purposes first stated above—research, publication and education. The difficulties are undoubtedly very great, and the first step must probably be to train those competent to deal with the complex conditions. But increased interest in the scientific aspects of the problems is full of promise for the future.

THE PROBLEMS OF ASTRONOMY

At the eighth annual meeting of the Astronomical and Astrophysical Society of America, held December 27 to 29, 1906, at Columbia University, New York, Professor E. C. Pickering, director of the Harvard College Observatory, on taking the chair, discussed three lines of work which he believed the society should pursue. According to the report of the editor, Professor Harold Jacoby, these are: First, by cooperation to carry out some great routine investigation too extensive to be undertaken by a single observatory. The best example of this was the accurate determination of the positions of the northern stars by European and American observatories, under the direction of the Astronomische Gesellschaft. Second, to bring together socially astronomers from all parts of the country, especially the older and younger men. The latter may think the work of the older men out of date, but they may find the experience of the older men and their personal acquaintance with the eminent men of still earlier date of great assistance. The older men have much to learn regarding new methods, and the extensive appliances at their command may often be employed to much greater advantage if they keep themselves personally in touch with the most recent developments of astronomical research. Third, the presentation of papers. While hitherto this has been the principal function of this and other societies it is not necessarily the most valuable. General discussions are more interesting and instructive than long technical papers. It may, therefore, be wise to follow the example of some of the engineering societies, and print abstracts of papers for distribution some days before the meeting. A brief statement is made by the author of each paper, and the greater portion of the time is devoted to discussion. The ideal conditions for meetings of the society would seem to be—a large hotel where all would eat and sleep under the same roof, and where the meetings could be held in the same building.

On the afternoon of December 28 a general discussion took place regarding neglected fields of work in astronomy, in which a large number of members took part, and the views expressed were varied and interesting. The president, in opening the discussion, cited a number of examples of fields of work, which seemed to him important but neglected. For example, in the astronomy of position the formation of a standard catalogue of stars uniformly distributed, having similar spectra, and of nearly the same magnitude. Many troublesome sources of error, like those due to magnitude and color, would thus be eliminated. The variation in latitude should be studied at a series of southern stations like those now in operation in the northern hemisphere. The systematic search for double stars of the ninth magnitude and brighter, undertaken at the Lick Observatory, should be extended to the south pole. Photometric measures of faint stars, of comparison stars for faint variables, of the components of clusters, and of nebulæ, are much needed. It is not known whether the spectra of nine tenths of the nebulæ are gaseous or continuous. A wide field is opened in the study of the spectra of bright variables when faint, and of faint variables when bright, of the distribution of faint spectra and of the components of clusters.

SCIENTIFIC ITEMS

We record with regret the deaths of the following men of science: Professor Dimitri Ivanovitch Mendeléef, the eminent chemist, director of the Russian Bureau of Weights and Measures; M. Henri Moissan, professor of general chemistry at the Sorbonne and director of the Institute of Applied Chemistry; Sir Michael Foster, professor of physiology in the University of Cambridge, secretary of the Royal Society from 1881 to 1903, president of the British Association in 1899, and member of parliament for London University; Professor Wilhelm von Bezold, director of the Royal Prussian Meteorological Institute; Professor Nicholas Menschutkin, professor of chemistry at St. Petersburg; Mr. William Wells Newell, of Cambridge, Mass., known for his researches in folk-lore, especially in connection with the Arthurian tales, secretary of the American Folk-lore Society; Professor Wilbur Samuel Jackman, who held the chair of the teaching of natural science in the School of Education of the University of Chicago; Dr. David Irons, professor of philosophy at Bryn Mawr College; Charles B. Simpson, entomologist of the Department of Agriculture of the Transvaal, and formerly of the U. S. Department of Agriculture, and Dr. John Krom Rees, since 1881 professor of geodesy and astronomy and director of the Observatory of Columbia University.

By special act of Congress Dr. James Carroll has been made a major in the medical department of the army, in recognition of his important work in yellow fever.—Colonel W. C. Gorgas, chief sanitary officer of the Isthmian Canal Commission, has been appointed by President Roosevelt a member of the commission.

M. Daniel Osiris has left by his will a sum of $5,000,000 to the Pasteur Institute of Paris.—Rensselaer Polytechnic Institute has received a gift of $1,000,000 from Mrs. Russell Sage. The money will be used for the School of Mechanical and Electrical Engineering. Mrs. Sage has also given $1,000,000 to the Emma Willard School of Troy.

THE
POPULAR SCIENCE
MONTHLY

MAY, 1907

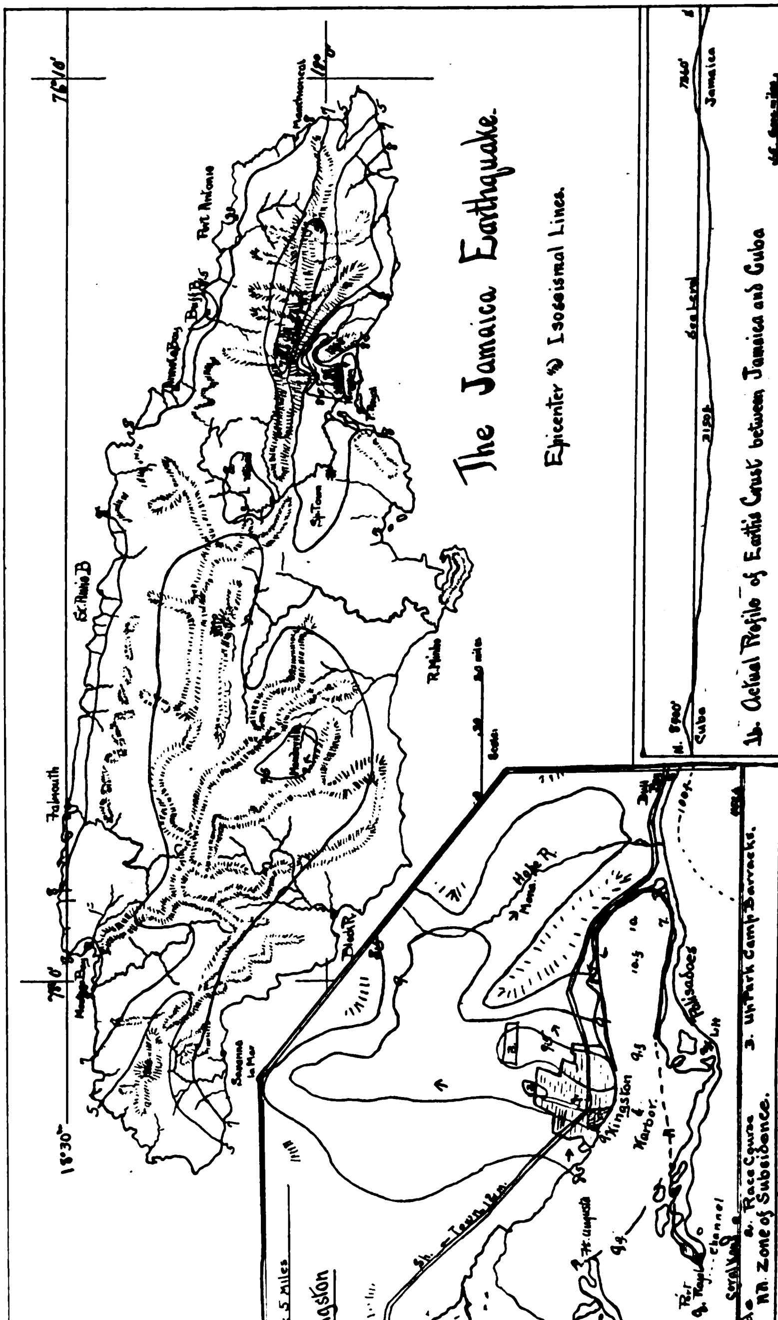
THE JAMAICA EARTHQUAKE[1]

By Professor CHARLES W. BROWN
BROWN UNIVERSITY

WITHIN nine months three regions in the western hemisphere, geologically closely akin but geographically distant one from the other, have been visited by earthquakes, causing an appalling loss of life and property. In all cases the disasters have been preceded by minor earth-shakings for years, and the areas were known to be in zones of earth-unrest. No warning, however, unless the tremors that occur at irregular intervals every month or two could be counted as such, has characterized these last disturbances. But these tremors must be regarded as the climax of a long-continued yielding to strain which has resulted in a series of minor breakings. This faulting culminated in a great fracturing of the earth's crust and a consequent destructive earth-shaking. The kindred conditions of these different areas appear to be, first, a considerable amount of differential relief only obtained where mountains are associated with marine depths; and, in the second place, where newer and less compacted sediments occur upon these slopes.

For several months previous to the afternoon of January 14, 1907, there had been no noticeable increase in the number or intensity of the customary slight shocks that occur in the Island of Jamaica every month or two. In Weather Report IV. of Jamaica, Mr. Maxwell Hall

[1] The writer desires to acknowledge his indebtedness to Dr. Charles D. Walcott, formerly director of the U. S. Geological Survey, and to J. D'Aeth, assistant director of Public Works; Mr. Maxwell Hall, resident magistrate; Mr. Charlton Thompson, harbor master, and to many other official and private citizens of Jamaica for their cordial cooperation and aid in the prosecution of the investigation.


The Jamaica Earthquake.
Epicenter and Isoseismal Lines.
1b. Actual Profile of Earth's Crust between Jamaica and Cuba
1a. Kingston
Scale: 5 miles
1. Parade 2. Race Course 3. Up Park Camp Barracks.
Zone of Subsidence.
Kingston
Harbor
Port Royal
Palisadoes
Port Antonio
Falmouth
Cuba
Jamaica

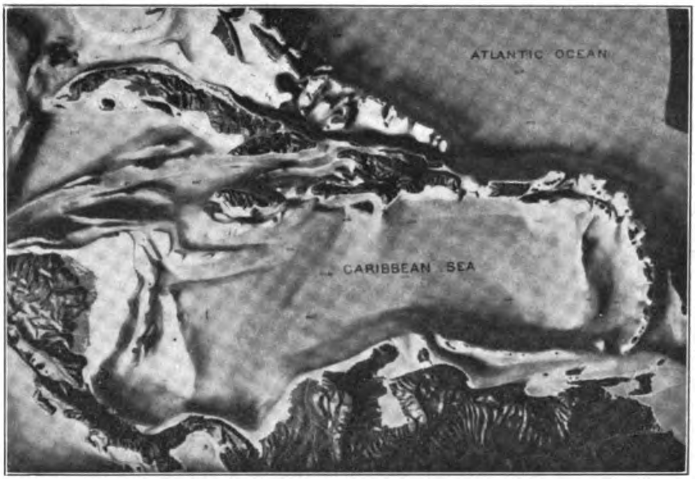


FIG. 2. PHOTOGRAPH OF COMD'R BARTLETT'S RELIEF MAP OF THE CARIBBEAN SEA.

has noted some twenty-six minor shocks that occurred from 1880 to 1886, and this number might be regarded as typical of the seismic phenomena in that region. A slight shock was noticed by many in November last, but the memories of the destruction of Port Royal by the historic earthquake of 1692 had been dulled by the interval of two centuries, and the Jamaicans had begun to think themselves in a region of comparative safety. Slight tremors and shocks caused but scant attention or notice on the part of a few of the people. Consequently, when the real cry of 'wolf' came, for the first second or so but few realized the danger. The slight tremor, however, instantly increased to a terrible vibration of the earth that threw down great walls and buildings and inside of a minute transformed the city of Kingston from a prosperous metropolis to a place of destruction and mourning.

In order to appreciate their relative importance and possible influence upon seismic activity, let us notice the topographic, geologic and bathographic conditions that exist at Jamaica.

The etymology of the word Jamaica, originating in two descriptive Indian words meaning 'well wooded and watered' and modified by the Spaniards to 'Xaymaca,'[2] is interesting, taken in connection with the historic topographic description of the island given by Columbus to Queen Isabella on his return from the West Indies—'a crumpled handkerchief picked up by the middle.'

The aptness of the simile can not be questioned when one sees the many steep knife-edged divides (typical 'bad-land' topography) rising abruptly in fifteen miles 7,400 feet to the misty Blue Mountain peaks that tower above the small inland valleys or the narrow plains that

[2] 'Handbook of Jamaica,' 1906, p. 23.

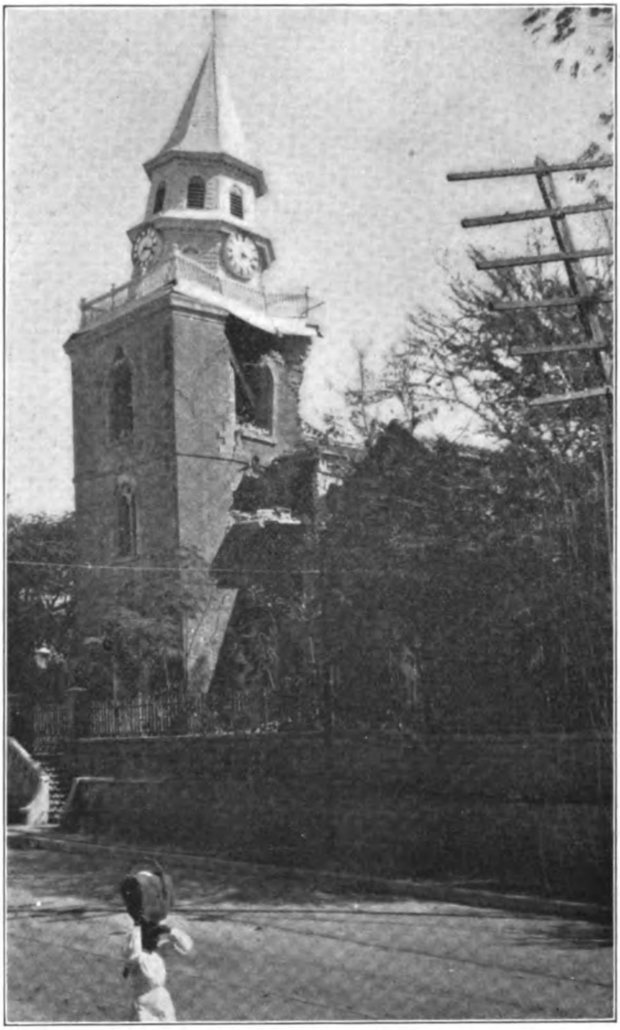


Fig. 3. Tower of Parish Church shattered and inclined to the East. Stopping of clock by shock.

fringe the seashore. These plains constitute the very small percentage of the island that is fairly level, and it is upon these plains that the larger towns and the larger plantations of bananas and sugar-cane are found. These level areas are made up of alluvial deposits, fans or sheet-wash brought from the adjacent ragged slopes by the rivers in flood time. Upon the rather bare slopes, occasional rectangular patches of light green show the location of small banana farms or 'pens.' But the more abundant and typical tropical verdure is found lower down on the fringing plains. The island has long been known for the abundance and variety of its tropical and subtropical products, due to the fertility of the limestone soil and the abundance of the rainfall, which varies largely, however, in the amount, from 10 inches at Port Royal to 126 inches some years in the higher regions.

Geologically, Jamaica is of comparatively recent age,[3] for its basal Blue Mountain series of sediments and intrusives is of late Cretaceous and Eocene times. This series makes up the mountainous backbone of the island, while the later Oligocene limestone overlaps the former series in a thick piedmontal formation covering two thirds of the island. The more recent alluvial and littoral formations were deposited during the period of uniform elevation following, and constitute the fringing plains of the island.

In the structural geology of Jamaica, the earliest axis of folding now evident is the northwest-southeast line of the Blue Mountains, with later east-west foldings along the more ancient line of orogenic movement which outlined the Greater Antilles in early Mesozoic times.[4] The writer has observed transverse faults in the Blue Mountain region, which undoubtedly indicate lines along which fracture may occur.

M. de Ballore[5] coincides with Mr. Hill's ideas regarding an east-west folding for the Antilles in postulating his theory of an anticlinal axis that marks the line of the Greater Antilles and a parallel synclinal belt immediately to the north of Jamaica, which coincides with the Bartlett Deep. In the photograph of a relief map (Fig. 2), the east-west elevation and depression are brought out strongly.

The bathographic relations of Jamaica are significant. We see that Jamaica and the other Antillean islands are but the higher peaks of a lofty and precipitous, but submerged, mountain chain. The tremendous differential relief of over 38,000 feet that exists in places in the Caribbean region apparently coincides with a zone of seismic and volcanic frequency. We know that the crust of the earth is always in a state of tension. This stress may come from the shrinkage of the earth, from the loading or unloading of the earth's surface through erosion or deposition, or from other sources. The resistance is lessened on a relatively steep slope (Fig. 1, *b*) where the points of application of this lateral pressure at the ends, not falling in the same plane, tend to produce a fracture. When a sudden slip in the adjustment occurs, the resulting jar is transmitted through the earth as earthquake waves.

Port Royal is at the western tip of a narrow seven-mile sand-spit that makes a natural breakwater to one of the finest harbors in the

[3] 'The Geology and Physical Geography of Jamaica: a study of a type of Antillean development,' Robert T. Hill, *Bull. Mus. Comp. Zool.*, Vol. XXXIV., Geol. Series, Vol. IV., September, 1899, p. 421.

[4] *Ibid.*, p. 164.

[5] 'Tremblements de Terre,' F. de Montessus de Ballore, 1906, Fig. 63.

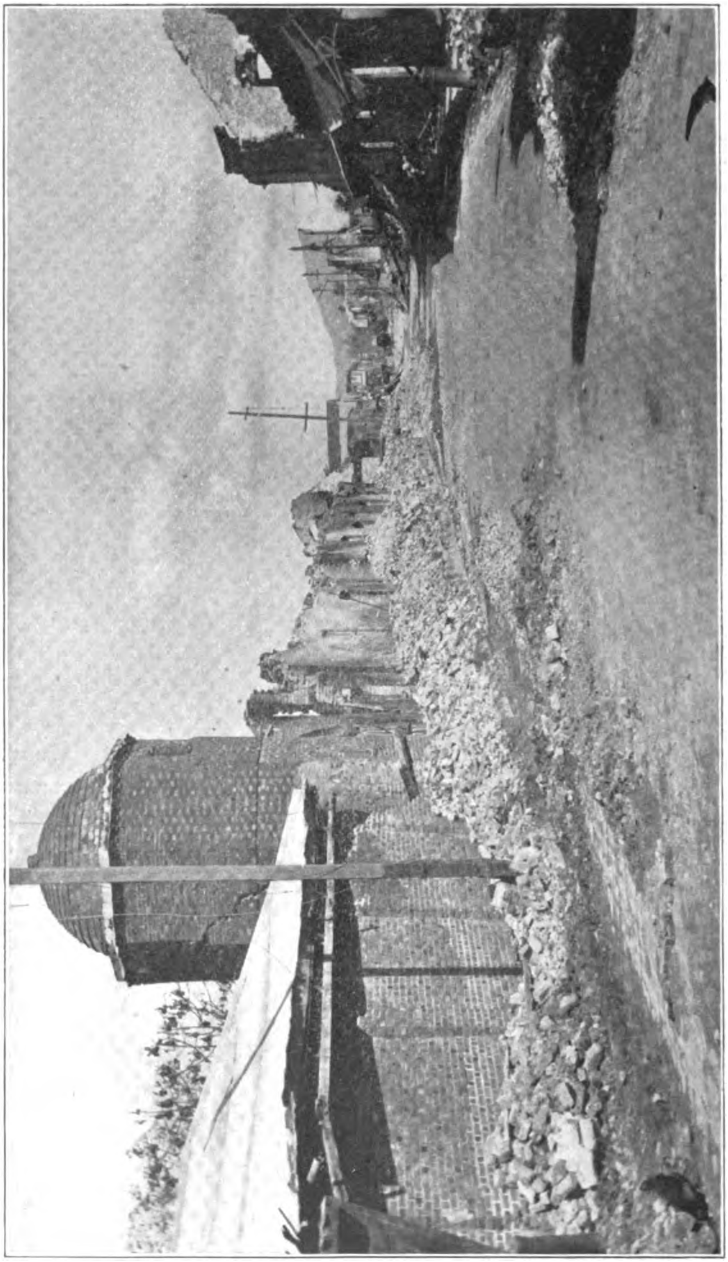


FIG. 4. STREET IN BUSINESS SECTION LOOKING NORTH. Western sidewalks covered with débris. Crack in fireproof, octagon building, showing angle of emergence of waves.

West Indies. When the town was for the most part submerged by the earthquake of 1692, this favorite site was abandoned for the Liguanea plain just across the harbor, and Kingston was founded on the largest of the fringing plains of loosely compacted sands and gravels. And here in this closely built city of 60,000 (and at Buff Bay opposite on the north shore) the destruction by the last earthquake was felt most keenly. Eighty-five per cent. of the buildings were injured or destroyed. Then came Kingston's old enemy, fire, and swept over ten or fifteen blocks of the business and warehouse section. (Figs. 4 and 5.)

The earthquake shock that brought disaster to the island of Jamaica began, according to the regulator of Mr. J. A. Soulette, at 3:33 P.M. Others record its arrival two or three minutes earlier. In various

FIG. 5. IN BURNED DISTRICT; THE NARROW HARBOUR STREET, looking east.

places on the island, as reported by local times, its occurrence varied from 3:20 to 3:45 P.M. In the investigation it was found impossible to plot any coseismal lines, for the reason that no accurate coordinated time exists in the island. Since the shock, however, there has been a movement on foot in Kingston to establish a system of accurate time-keeping throughout Jamaica. The shock lasted about thirty-five seconds, varying in length with the location and geological position of the observer. At the east end of the island some noted a duration of sixty seconds; on the north shore a length of ninety seconds, while at other points near by the duration reported was anywhere from five to forty seconds. The slight preliminary tremors were felt immediately before the main shock, and the noise and roar was heard slightly before the coming of the major vibrations. One man, used to earthquake

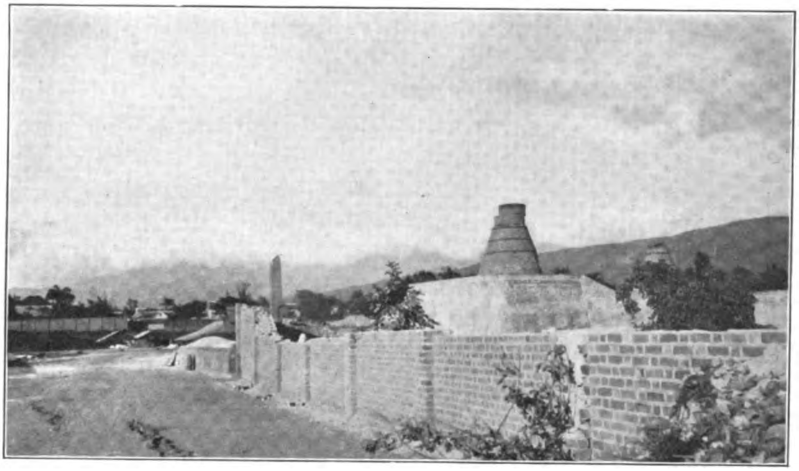


FIG. 6. LOOKING NORTH IN GENERAL PENITENTIARY BRICK-YARD. Upper third of brick chimney, upper part of smokestack (to guys), and upper ring of lime-kiln; together with large part of the brick wall thrown to the east. Fissures made in ground in lower part of view.

countries, hearing the sound from the preliminary tremors, rushed out-of-doors into the street only to be thrown down toward the west by the violent shaking. He dragged an injured companion a hundred feet or so during the slight lessening of the violent shock, and then felt the second climax of a slow undulating character pass underneath. This experience is like the phenomena of double earthquake shocks which have come to Jamaica in past years, and also has characterized many of the sequent shocks. Another man repeated his actions and found that he could jump through the fallen wall of the house and then over

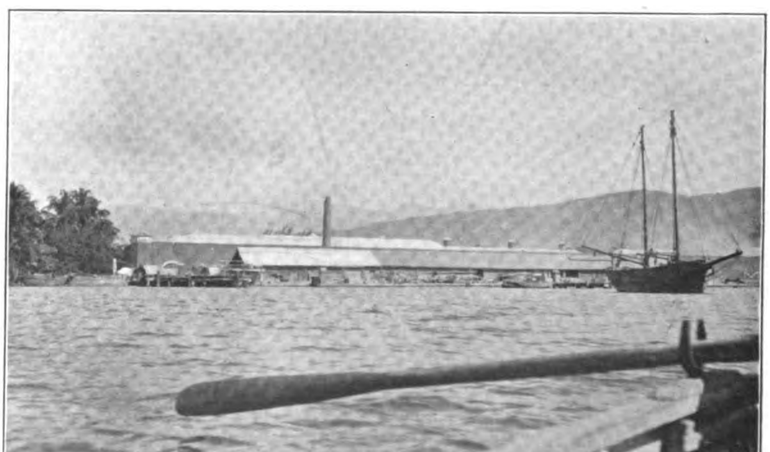


FIG. 7. LOOKING NORTH TO LANDING PLACE AT GENERAL PENITENTIARY. Massive walls cracked; a section of the eastern wall was demolished. Upper part of chimney overthrown to east.

a low fence and get into the street in about forty seconds. The increase and decrease of the tremors are so gradual that it is very difficult for an observer to tell just when the shock comes and when it ends. From the majority of the testimony it is evident that in this disaster the movement quickly reached the major climax in about ten seconds, then lessened in intensity for about ten more, then gently swelled to a second and minor climax and disappeared in a total of about thirty-five seconds.

While there were apparently no preliminary shocks at Jamaica, there have been many sequent vibrations of the earth, more or less severe. The press has chronicled one on February 23, which was the strongest since the earthquake, and another one also was noted on March 22. Mr. Maxwell Hall[6] has noticed some eighty shocks after the main shock on January 14 to February 5, several of them shaking the whole island, while others were of local extent. On the early morning of January 28 one small shock awakened me instantly by a slight shaking of my cot in the tent in which we were sheltered. The continuance of the motion gave one a sense of insecurity and unsteadiness, and brought with it a slight tinge of dread and nausea. My first impression upon waking was of a rushing, whistling sound from the southwest; it increased and passed overhead, rapidly lessening and disappearing. It was very similar in sound to the approach and passing of a large flock of ducks flying low. Then from the race-course, only a quarter mile distant and only a short time quieted, came the cries of the frightened negroes and the howls of the numerous dogs with which Kingston is cursed, and the crowing of the many roosters in the trees —as they did about every hour during the night. The shock felt on board the moving Port Antonio train produced a feeling as if the coaches were running upon the sleepers and at the same time swaying so much that it seemed as if they would topple over to the southeast. No damage, however, was done to any of the rolling stock or to the roadbed. In none of the many tunnels was any displacement observed. A man driving on the road suddenly felt his vehicle thrown in an angling position across the road and it seemed difficult for the horse to keep its footing. It was observed, however, that motion sometimes counteracted the vibration of the ground and made the latter imperceptible.

The sketch map (Fig. 1) shows by the isoseismal lines the relative intensity of the shock at Kingston as compared with other places on the island. It has seemed rather strange that the most intense destruction should happen to occur just where a large number of buildings are found. But in the case of Kingston, the gravelly foundation in proximity to the epicenter readily accounts for the destruction.

[6] Personal communication to the writer.

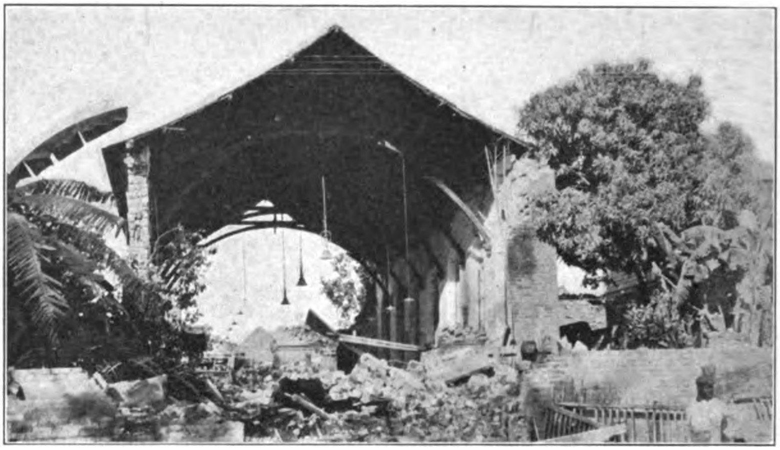


FIG. 8, *a*. EAST AND WEST GABLE ENDS DESTROYED by SHOCK.

From the data available, the dependence of earthquakes in intensity upon topography is well emphasized. Loosely compacted fringing and alluvial plains extended the intensity farther than the more compact and elastic mountain regions. Not only do these less elastic plains give a greater amplitude to the waves and cause greater destruction, but apparently the earth-waves are affected by plains indented in hills as sea-waves change their direction in entering the arm of a bay. The arrows (Fig. 1, *a*) indicate generally the direction of the wave motion. In the middle of the Hope River Valley at Mona Plantation an observer noticed the motion pass him and then saw the landslide occur at the mouth of the river to the southward. As the wave passed over the cane-fields, a motion was observed similar to that produced in a field of grain by the wind. The direction here was at right angles to the path of the wave-motion only five miles away at Kingston, situated on the western slopes of Long Mountain. The motion approached the island from the southwest, changing on the land its direction and intensity with the change in the nature of the material through which it passed. In the lower part of the city of Kingston the path of the movement was well marked by the overthrowing of walls, piers, statues, monuments, large chimneys and a similar movement toward the east of even large marble slabs covering graves (Figs. 3–9). Northward from the city the motion appeared to come more from the south, and the northern walls showed the greatest damage; and westward, the path of motion appeared to swing so that it came from Kingston. The absence of any large buildings, away from the villages and cities, made the plotting of directions rather difficult, for the lightly-built mud-wattled huts were not affected by the shock and tests by hearing are very unreliable. But there was a general diminution in intensity away from Kingston;

FIG. 8, *b*. EAST AND WEST WALLS CRUSHED.

decreasing rapidly eastward, less rapidly westward and still less so to the north. Haiti did not feel the shock, neither was it felt at Colon or at Grand Cayman, 175 miles west, but Santiago, 120 miles north, experienced a slight shock.

Cracks in buildings, which at Kingston dip some 50 degrees east, are always perpendicular to the path of the emergence of earthquake waves. Hitherto, the intensity area and epicenter have been regarded as synonymous. But the dip of the angling cracks at Kingston points to a locus of disturbance much to the west of that city, while the lines of isoseismals indicate the intensity area in the eastern half of Kingston. It may readily be imagined, then, that the area of greatest destruction may not be directly above the focus. Suppose a highly elastic rock is there situated, and some distance away is found a plain of loosely-formed material. The destruction in the latter area will far exceed that in the former in spite of its favorable location. Until we register the actual amplitude, wave-length and period and, with the elasticity of the rock underneath, calculate from the more readily-discerned data on adjacent but less elastic media the changes that have occurred in the wave-motion, it will be difficult to determine with accuracy in a region of rocks of widely varying elasticity the location of epicenters. For outliers of rock in plains must deflect, refract and reflect wave-motion and even shadow areas in these plains. The only conclusion then is that the eastern end of the Liguanea plain was the nearest area to the real epicenter that by nature of material would give the greatest amplitude to the destructive epifocal waves. Further, the angle of emergence at Kingston coordinated with the proximity of a probable epicenter, together with the limited area of disturbance, indicates a shallow origin of about three miles.

FIG 9. SHOWING THE EAST WALLS OF THE JAMAICA CLUB. Crushing of the walls by the roof and of the first story by ceilings and partitions. The majority of the first stories remained intact.

FIG. 10. STATUE OF QUEEN VICTORIA, TWISTED AN EIGHTH TURN COUNTER-CLOCKWISE FROM THE SOUTH.

The line of intensity of the earthquake destruction apparently extended to a greater distance northward than to the east or west. For at Buff and Annotta Bays on the north shore, the destruction was but little less than at Kingston. Furthermore, the shock was felt at Santiago to the north and not at Haiti to the east or on land to the west of Jamaica. The inference is that the locus of the disturbance originated in a line of north-south faulting rather than in an area of less linear extent. The north-south fault-lines extending throughout the island, as noted before, and some probable fault-lines extending in a similar direction through Cuba (marked by sharp valleys) may indicate in a general way the direction of possible faulting at the present time. It might be noted that this line of faulting lies at a considerable angle with the general trend of the Antillean folding. The beautiful mountain road from Kingston to Newcastle was in the line of greatest intensity. But though spurs showed considerable destruction and in places the road slipped off the face of the steep slopes (Fig. 11), or portions of the hills slipped down on the road carrying it away or obliterating it by landslides in many places, yet the destruction was caused more by the unstable position of the road, or of these masses of earth, rather than by the intensity of the shock. At Newcastle, moreover, the buildings for the most part were not damaged to any great extent, except as their location on a terraced slope or on the crest of a short divide would place them in a position of unstable equilibrium. Similar destruction might be caused by a severe rain-

FIG. 11. DESTRUCTION OF THE BEAUTIFUL CARRIAGE ROAD TO NEWCASTLE, built on the steep slopes of the Blue Mountains.

storm, or, in the northern countries, by frost action as well as by earthquake waves.

From the investigation of the many cracked walls at Kingston, the amplitude of the wave motion (as one might expect on alluvial foundations) was considerable. Spaces from half an inch to two inches were left in massive walls. Floors and ceilings were pulled from the shallow supports in many cases and caused destruction in more instances than would have been necessary had there been greater foresight used in the manner of building. From an open circular well of masonry some twenty feet in diameter water was thrown up some eight feet and over the northeastern lip of this well. A brick pier in a fence was thrown to the eastward beyond its arc, some two thirds the length of its radius. At the same place large slabs of marble were moved along

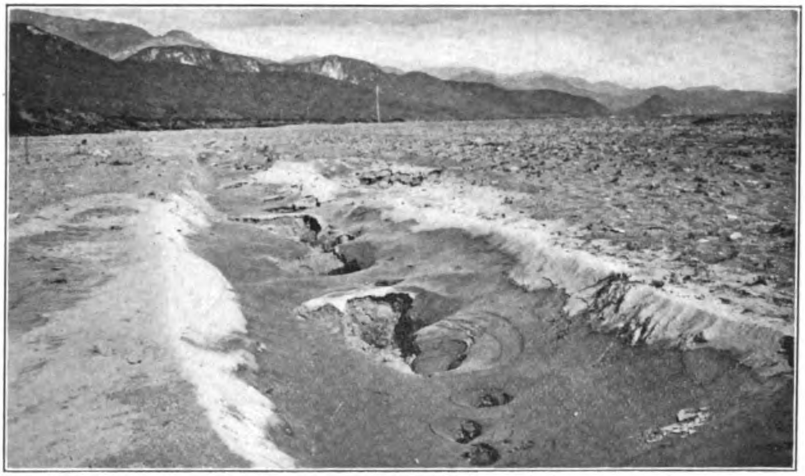


FIG. 12, *a* LOOKING EAST ALONG BELT OF FISSURING AT BASE OF THE PALISADOES, showing one of several parallel fault planes in the sand, with craterlets of mud.

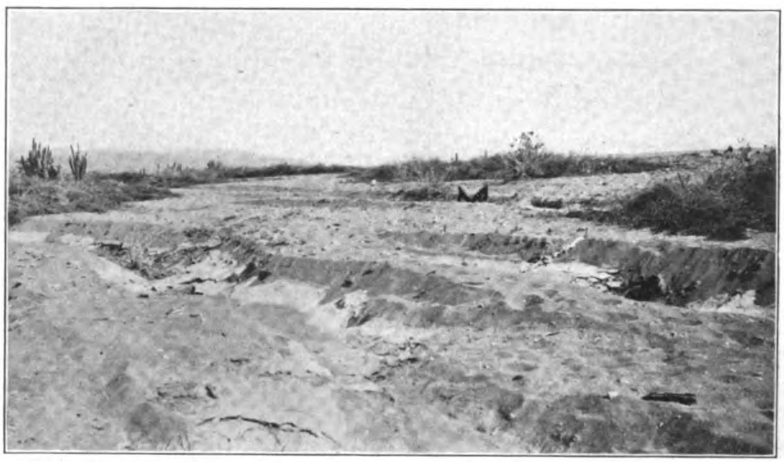


FIG. 12, *b*. LOOKING SOUTHEAST ACROSS FAULTED BELT.

on their cement base to the eastward some three inches or more in spite of the attendant friction. The amplitude was probably less than an inch at Kingston.

The speed of the various waves in this earthquake can only be approximated. During a slight shock that occurred afterwards, of about one third the intensity, from an interrupted telephone conversation from Kingston to Port Antonio, it was estimated that the wave traveled about two thousand feet per second. As yet no data have been available concerning the breaking of the cables, and as to the exact time or speed as marked by such fractures. The Panama cable was broken in two places, one four miles and the other some twenty miles offshore from Bull Bay, but so covered was it with débris that a couple of miles

FIG. 15. NEARER VIEW OF SUBMERGENCE AT PORT ROYAL, looking south. Most of the area now covered by water in the photograph was formerly land.

or so of the cable had to be abandoned. The preliminary tremors were heard before being felt and probably were slower than sound-waves. With the increase of speed that comes with the augmentation of intensity of earthquakes, it is probable that the rate of the major vibrations was about ten thousand feet per second.

As has been previously stated the shock was a double one; the first climax apparently came from the west, while the second one, less disputive and more undulating in its character, apparently came more from the southward of Kingston. These two directions of vibration resulted in an almost universal gyratory movement of columns, statues, piers, sections of brick chimneys, and even of buildings, in a counter-clockwise (Fig. 10) fashion.

Geologically, earthquakes often are not very important. In the case of the earthquake at Jamaica, however, there apparently was a

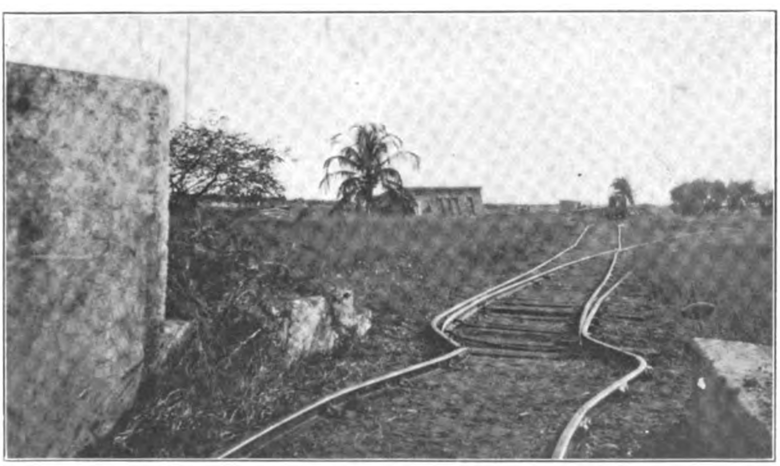


FIG. 16. TWISTING OF RAILS AND TILTING OF BUILDINGS IN VICTORIA BATTERY, PORT ROYAL, BY SUBSIDENCE.

zone of fissuring and subsidence from a hundred yards to three hundred yards in width (Fig. 1, *a*, *AA*). It started at the western part

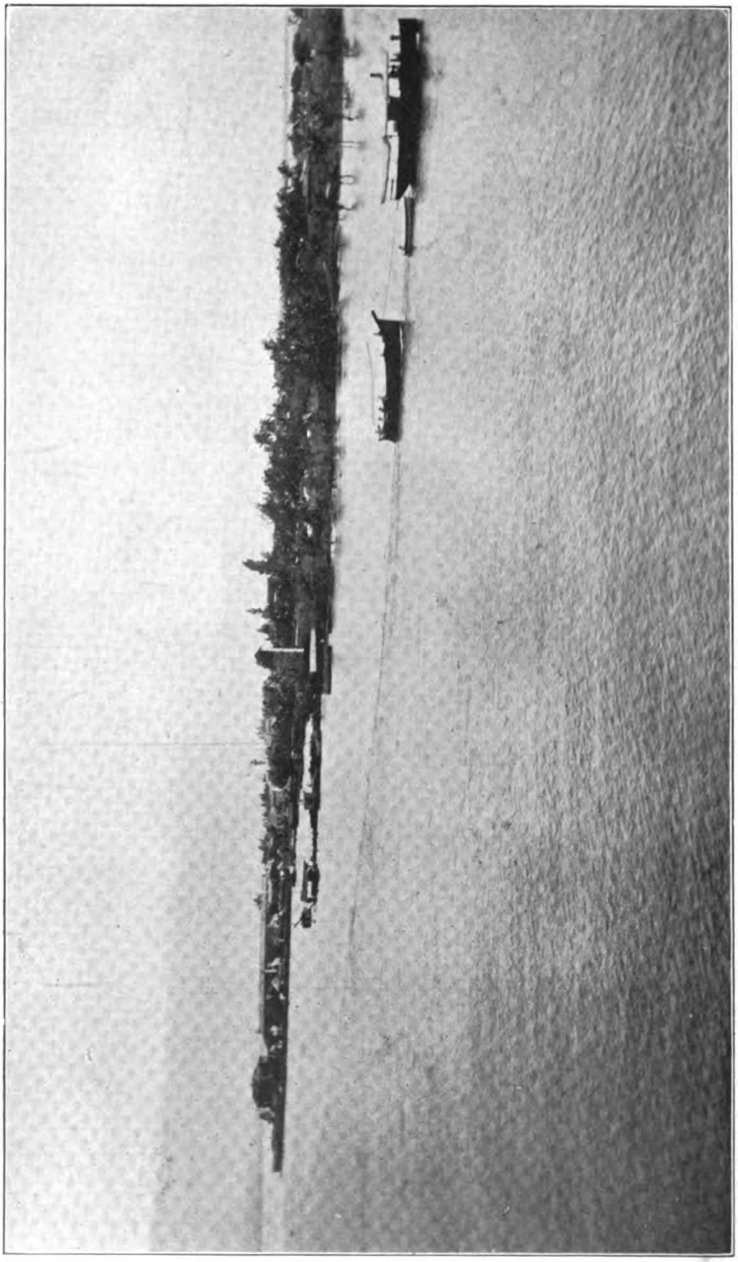


Fig. 14. Looking East toward Port Royal showing Submerged Palms and Battery Casemates (in line with tower). Old Port Royal formerly extended northward from the point at the left.

of the city of Kingston, ran along the water front encircling the harbor, and continued along the line of the Palisadoes, reaching its greatest destructive effect at Port Royal. One arm of this fissuring followed up the River Cobre to the carriage road. From soundings taken by the kindness of Mr. Charlton Thompson, harbor master, it was ascertained that in several places along the edge of the harbor, the bottom had sunk from old soundings of a fathom and a half to over six fathoms, and that on the harbor side of the base of the Palisadoes a series of step-faults reached a maximum depression at the shore to the north of four fathoms (Figs. 12 and 13). This zone of disturbance continued, as far as could be traced, in an interrupted line along the Palisadoes, and caused a maximum depression at the western tip of Port Royal, where the buildings were tilted by the sinking and a hundred yards or more of land were submerged to a depth of from eight to twenty-five feet (Figs. 14–16). This fissuring of the earth was caused by the repeated tearing apart and closing of the earth's crust, accompanied generally by the ejection of water, sand and mud, sometimes to the height of three or four feet, but the subsidence prevented the forming of any cones about these craterlets. The sands first thrown up were afterwards covered by a layer of mud.

To account for the unique line of fissuring and subsidence is difficult. It was noted that considerable disturbance took place at the shore line where the earth vibrations were refracted in changing from the medium of one elasticity to a medium of a different elasticity. But the middle portions of the harbor were stable and the channel was unchanged, though a beacon light near Fort Augusta was broken off. In this limestone country, solution by underground waters might be sufficient to account for the sinking of a small area like the harbor at Kingston. But the harbor did not sink—only a small encircling zone, and that located either on the shore or slightly offshore. The continuous tearing apart and closing of these fissures, covering a few hours' time as it did in some instances, might account for the hydraulicking of the loosely compacted sands and gravels in the zone of fissuring, and allow subsidence. Again, ground-waters may have caused considerable solution of the limey constituents where the waters entered the harbor. No theory as yet satisfactorily accounts for this peculiar subsidence. At the eastern end of the harbor at Rock Fort a considerable change in underground drainage was observed, where a small spring was increased to a stream eight feet wide and six inches deep.

It was here at the Rock Fort penitentiary quarry that a guard gave me the only reliable account of a sea wave. After a few moments had elapsed and the convicts had run from the landslides on the face of the quarry and gathered around him for protection, the sea retreated for a hundred feet and then advanced inward upon the shore about sixty feet in a low wave a couple of feet high. Ocho Rios, near

FIG. 13. LOOKING TOWARDS KINGSTON, ACROSS HARBOR FROM BASE OF PALISADOES, showing width of sunken belt. Soundings of four fathoms were taken where the tree-tips emerge from the water, formerly near the old shore-line.

St. Anne's Bay, on the north shore, also had its harbor emptied for about seventy-five yards, after which a small incoming wave was followed by gradually lessening oscillations. A careful search ten days later along the other places of the harbor and coast line, however, revealed no trace of any sea wave, even of slight degree.

Thanks to the energy of the department in charge of the waterworks and to the good fortune that caused no important breaks in the system, Kingston was shut off from its water supply for only two hours. Some of its cement reservoirs situated near a large wrecked school building showed no damage. The pipe that carries the city's sewage eastward to the sea at the base of the Palisadoes, however, was broken at several places along the zone of fissuring, and its linear extent, like that of the water pipe along the Palisadoes, was marked by rifting in the earth. A prompt repairing of the breaks in these two systems undoubtedly saved the city from an outbreak of destructive pestilence.

Arches in buildings apparently withstood the shock to a notable degree, whether transverse or parallel to the line of the earthquake motion. Generally when built in houses they preserved the parts around them. The Institute, a building in which some two hundred delegates had assembled in the first session of the West Indian Agricultural Conference, is built on two lines of arches at right angles to each other. The Institute was damaged, but withstood the shock. The great destruction of brick buildings in Kingston was doubtless due to the fact that poor mortar and dry bricks were used in the construction. The mortar generally appeared to be rather porous and usually the cracks in the wall followed the mortar, though at Up Park Camp, where the bricks were laid in cement mortar, the cracks passed through the bricks.

The streets were narrow (Figs. 4 and 5), so that the falling wall of even a two-story building would block the street, and many persons escaped from falling buildings only to be crushed in the choked narrow streets. A cement floor may help preserve a building from destruction. In many cases it could be seen that if the floors had been well tied to the walls and the walls themselves held at the corners, a great lessening of the destruction would have resulted. On account of the white ants foreign woods are, unless creosoted, difficult to use, but some frame houses showed but the slightest effect of the earthquake shock. The 'barrack' or 'noggin' structure, much used in earthquake countries, apparently suffered nearly as much as other brick walls.

Jamaica lies in a region of great differential relief and consequent stress. The earthquake was confined in its area of greatest destruction to small limits upon alluvial detrital material, where the amplitude was increased to bring about this effect, varying with the heterogeneity of material. The origin of the shock was comparatively shallow and the earthquake was local in character. While there was a general distinct rotary motion induced by two components of the vibrations, the major component came from a westerly direction. There were few evidences of sea waves, but there was a unique zone of fissuring and subsidence about the harbor of Kingston. Finally, the disasters at San Francisco, Valparaiso and Kingston should teach the lesson that in the case of cities located in a danger zone (where there are many recurring shocks of slight degree), there is always a possibility of the coming of a disastrous shock; that certain types of buildings should be built and streets laid out with that possibility in mind; that water, sewage and lighting systems should be planned in sections, and that as far as possible a city should not be located nor large edifices erected upon uncompacted rocks and soils.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DE LAND
PITTSBURG, PA.

IN November, 1876, Graham Bell perceived the value and efficiency of the metallic circuit and advised its adoption for telephone service to overcome the inductive annoyances. On February 1, 1878, the parent Bell company recommended the use of metallic circuits for

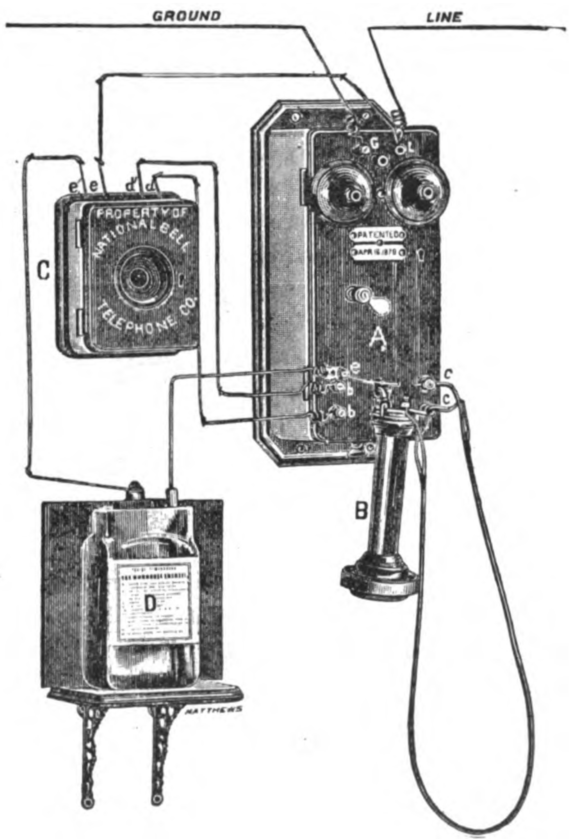


FIG. 30.

exchange service, although only three telephone companies had exchanges in operation that month. But many of the local companies could only perceive that the introduction of a metallic-circuit system meant double the cross-arm space, stronger poles, double the terminal equipment, the rapid displacement of open wires with cable, etc. Then, in August, 1877, Graham Bell showed the advantage of twisting 'the direct and return wires around one another, so they should be absolutely equidistant from the disturbing wires' in order to neutralize the effect of the inductive current and eliminate the noise.

Many experiments were made to invent an improved transmitter that would overcome the inductive effect and yet retain the marvelous simplicity of the hand telephone, with its entailed low cost of maintenance. But eventually it was perceived that the displacement of the magnets in the simple self-contained telephone was possible only

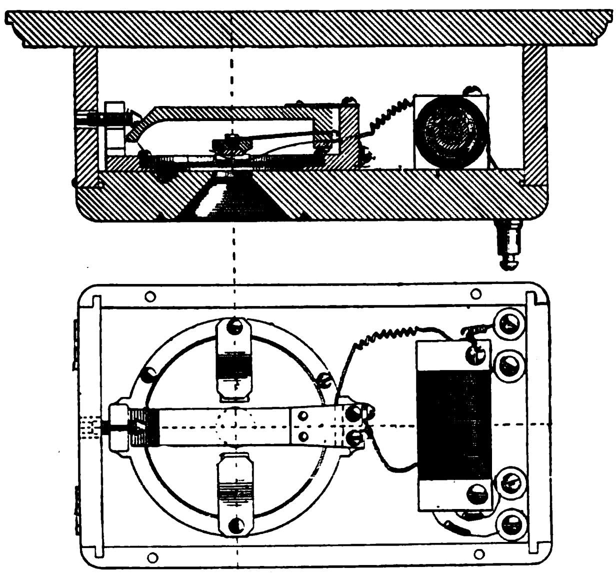


FIG. 31.

through the introduction of a battery current and the employment of much mechanism that has always carried relatively heavy maintenance charges.

In the winter of 1878–9, the more progressive companies began to install the Blake transmitter in combination with the rubber-encased Bell receiver and the magneto bell. At the close of 1878, 246 Blake transmitters were in service, and by July 1, 1879, the number had increased to 7,000. On noisy circuits this change afforded a marked improvement in service that was highly appreciated by local subscribers. Several modifications in the form of these telephone sets (Fig. 30) were sent out before a standard type was selected. Even then, as there were several factories licensed to manufacture under Bell patents, the output of each, while not essentially different, bore distinctive trade-marks. In each the battery wires were led into the bell box so that the battery circuit might be under the control of and closed and opened by the telephone hook switch. Interior and sectional views of the Blake transmitter are shown in Fig. 31. With each of these early Blake instruments a circular was sent stating that it

can be used only as a transmitter, and requires a telephone to hear with. This is the most complete and perfect set of instruments that can be used for telephonic communication. It will transmit the faintest whisper with perfect distinctness.

It is a fact that no modern transmitter exceeds the Blake in clearly and distinctly reproducing the articulation of the subscriber. But owing to the mechanism employed in its single contact form, it proved deficient in volume or power required on noisy and on long suburban lines. Again, its first cost was comparatively low, and the Blake and similar types of transmitters possess the striking advantage over the old hand telephone of being placed on a local circuit, thus removing their varying resistances from the line circuit, to the improvement of the qualities of transmission. The old hand telephone and the early box magneto telephone formed a part of the main-line circuit, thus materially increasing its resistance.

The first Blake instruments were larger in whole and in part than the transmitter so familiar to all telephone users, while the screw that controlled the proper adjustment of the electrodes projected through the box, thus making it possible for the subscriber to adjust the instrument for long circuits or short lines, regardless of the mood he might be in. It only required a little experience to teach the local companies that the wiser plan was to have trained telephone inspectors do the necessary adjusting. So the adjusting screw was put inside the box and the door fastened with lock and key.

There is a wide difference between the underlying principles of Bell's self-contained transmitter and his variable resistance transmitter, both of which were exhibited at the Centennial. The microphone, or carbon, or battery transmitter, now in use on nearly all telephone lines, belongs to the variable resistance type. Unlike the early hand transmitter, it does not generate current, but serves as a voice-governed mechanical regulator of the flow of current chemically generated in a battery.

After Graham Bell had shown how to solve the problem of speech transmission, many other inventors were naturally quick to suggest commercial improvements. A few worked hand-in-hand with Graham Bell and gladly contributed to his success. Among this number was Francis Blake, Jr., who invented the transmitter bearing his name and which was the only transmitter used on a majority of the Bell lines prior to 1893. Mr. Blake was a Christmas present in 1850; graduated from the Brookline, Mass., High School in 1866; entered the United States Coast Survey, and during the next three years assisted in the transcontinental longitudinal determinations. Finding it necessary to make many experiments in determining the velocity of telegraphic time signals over long circuits, he made a thorough study of electricity. In 1869 and again in 1872 he was in Europe and made all the observations in the third and final determination of the difference of longitude between Greenwich, Paris and Cambridge. Subsequent observations by European astronomers confirmed his work. During 1874–6, he was preparing the results of his transatlantic work for publication, and during this period became acquainted with Graham Bell. On April 5, 1878, he tendered his resignation, which was accepted with the greatest reluctance to date April 15. During the four years that had elapsed since his return from Europe he had devoted all his leisure to experimental physics. It is recorded that in carrying on these experiments

he had become an enthusiastic amateur mechanic; so that at the time of his resignation he found himself in possession of a well-equipped mechanical laboratory, and a self-acquired ability to perform a variety of mechanical operations. Under these conditions what had been a pastime naturally became a serious pursuit in life; and within barely a month of his resignation, April 5, 1878, Mr. Blake had begun a series of experiments which brought forth the Blake transmitter.

Other workers were also successful in serviceably utilizing the 'loose contact' or microphonic principle in the telephonic transmitter. In January, 1877, Emile Berliner devised his well-known transmitter, for which he filed a caveat on April 14. It was referred to in the Washington *Critic,* May 18, and on June 4, 1877, he filed an application based on his caveat. The patent was issued January 15, 1878. On April 27, 1877, Thomas A. Edison filed his application for a patent on a battery transmitter; while in December, 1877, Professor Hughes commenced his now famous microphonic experiments, which were followed by Hunnings's employment of carbon granules. One of the first of the Berliner transmitters is illustrated in Fig. 32

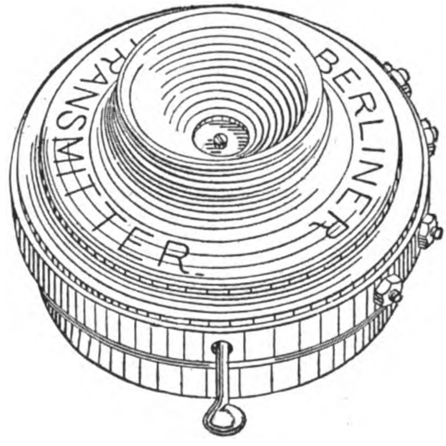


FIG. 32.

Referring to some of these experiments with carbon electrodes, Sir William Thomson (now Lord Kelvin) wrote:

It does seem to me that the physical principle used by Edison in his carbon telephone, and by Hughes in the microphone, is the same, and that it is the same as that used by M. Clerac in the variable resistance carbon tubes which he had given to Mr. Hughes and others for important practical applications as early as 1866, and that it depends entirely on the fact, long ago pointed out by du Moncel, that increase of pressure between two conductors in contact produces diminution of electric resistance between them.

Bell's hand transmitter was not only a telephone complete in itself, but was a self-contained generator of the alternating-current type. It was operated by the voice creating sound waves that in turn generated electric waves through the movements of the diaphragm. These electrical waves were similar in form to the sound waves and were transmitted to the receiver and there changed back to sound waves. When in operation the flow of the current, and every variation in its strength, was dependent on the varying motions of a diaphragm moving in a magnetic field; that is, on the speed of an armature of a miniature dynamo driven by the spoken word. In other words, in the hand telephone respondent vibratory motion of a soft iron induction armature in a magnetic field was the essential element in the successful transmission of speech.

In the Blake and other forms of variable resistance transmitters, whether single or multi-contact, there is no electro-magnet and no armature. A battery, usually of the sal-ammoniac type, supplies a constant current, the flow of which is regulated by increasing or decreasing the pressure of the diaphragm against the carbon button, the changes in pressure being governed by the impact of the changing sound waves on the diaphragm. Thus a carbon transmitter is not so sensitive, nor does it possess that delicate responsiveness so noticeable in a magneto transmitter. It matters little what may be the nature or character of the diaphragm in a variable resistance transmitter, so long as it is sensitive enough to reciprocally respond to the sound waves produced by the vocal cords. But only a soft iron inductive diaphragm will serve in the magneto type of transmitter.

In the White or solid-back transmitter, now so familiar a part of Bell equipment, the single-contact feature of the Blake transmitter is succeeded by a multi-contact arrangement composed of two carbon electrodes made of the hardest of pure carbon separated by carbon granules. The selected granules insure a multitude of contacts, and talking qualities that are unexcelled.

In all these variable-contact transmitters the current is always knocking at the carbon gateway and seeping through. When the telephone is not in use, the carbon offers just sufficient resistance to prevent the current from forcing the gate wide open. When a person is talking, the vibrations of the diaphragm decrease the resistance of the carbon and enable the current to flow through the partially or wholly opened gateway.

Unlike the hand telephone in every respect, the Blake transmitter consisted of a small black-walnut box, nearly square in form and having a funnel-shaped hole cut in the door to serve as a mouthpiece. Within the box was a soft iron diaphragm and suspended parallel to its center was a polished button of pure carbon; between the two hung a German-silver spring bearing a pellet of platinum which barely touched the center of the carbon. When the Blake transmitter was in use, the impinging sound waves pressed the diaphragm against the platinum and forced it with varying pressure against the carbon button. This changing pressure varied the resistance offered to the flow of the battery current, which pulsated through the carbon and into the primary winding of an induction coil or transformer, where it was converted into an alternating current through the inductive effects of the secondary winding and passed out in undulating or wave-like form into the line or subscriber circuit, thence through the copper wire in the green-covered telephone cord attached to the receiver, and on into the wire wound on the electro-magnets. Energizing the latter varied the attractive or pulling power of the pole pieces, thus causing the receiver diaphragm to vibrate in a manner exactly reproducing the vibratory motion of the transmitting diaphragm and setting up a series of sound waves in the receiver exactly corresponding to those produced by the vocal cords of the speaker.

So sensitive is a properly adjusted telephone diaphragm that its vibrations may cause several hundred thousand variations a minute in pressure of platinum point on carbon button in the Blake transmitter, or between carbon granules in certain other microphonic forms Naturally the amount of current thus passing through this carbon gateway is extremely small, depending principally on the pitch of the speaker's tone and the physical condition of the line. Under ordinary circumstances and with both telephones and a complete copper circuit in good condition, distinct transmission of speech only requires a maximum generation of about one tenth of a milliampere of current at any one period, or only a millionth part of the current required to light an incandescent lamp. Again, probably only one fourth or less of even this infinitely small amount of current reaches the electro-magnets in the receiver, the other portion being used up in overcoming resistances. Where the circuit is three or four hundred miles in length, it is probable 'that only about one one-hundredth of the original current produced at the transmitting station is finally utilized at the receiving station.'

Where operating companies desired a less expensive instrument than the standard Blake set, for use of small users of service, only willing to pay a low rate, a much cheaper set (Fig. 33) was supplied. This set was originally intended to be used only on private lines, or for educational purposes; that is, to gradually acquaint the subscriber with the convenience and value of having a telephone in the home. A glance at Fig. 33 shows that *A* is an electric tap-bell, *B* the hand telephone or receiver, as it is now called, *C* the Blake transmitter, *D* 'an automatic switch on which the telephone must be hung when not in use,' and *E* the signalling key.

Installing the regular Blake telephone sets in residences was not an easy task by reason of there being three separate parts to find location for, the magneto bell and receiver, the Blake transmitter, and the batteries (Fig. 30). So much opposition was encountered in handsome homes where the owners objected to the disfigurement of walls,

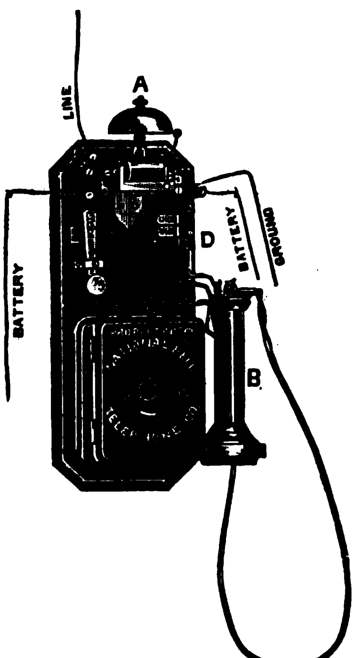


Fig. 33.

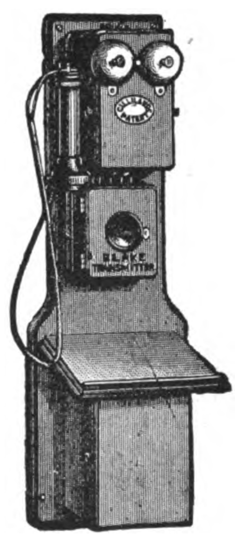


Fig. 34.

that immediate efforts were made to devise more compact forms. Finally the different parts were all merged into the oblong set or wall telephone (Fig. 34) so familiar to users of telephone service. An elaborate Gilliland set, designed for use in the better class of residences, is shown in Fig. 35. The battery was kept in one drawer, and pencil, memorandum book, etc., in the other. The Law set used in New York City in 1879–80 is shown in Fig. 36.

Some years ago it was asserted that all the credit for this serviceable arrangement belonged to a grocer in Denver, who, all unconscious of the value of the idea to telephone companies, fastened the magneto bell to a partition in his store, attached the Blake transmitter below the magneto, and screwed an empty soap-box underneath the transmitter. He placed the batteries in the box and made the top of the box serve as a desk on which to record orders received over the telephone. It is said that the partition suggested to an observant telephone man the back-board of the present telephone set, while the soap box suggested the usual battery-box. At any rate, about that time began the movement towards uniformity in equipment, economy in maintenance and artistic serviceability in installation. No matter how expert the installer, it was a difficult task to quickly and neatly install several parts of a telephone set, where each part had to be firmly attached to the wall, especially in handsome residences. Thus the more compact forms were welcomed innovations. But they had one

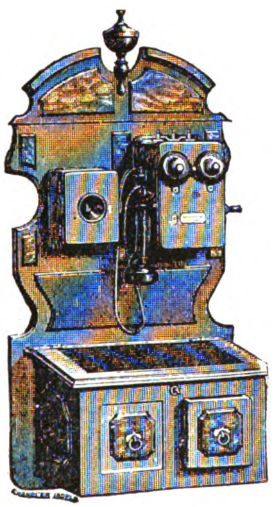


FIG. 35.

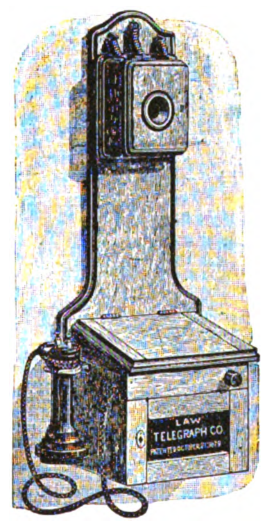


FIG. 36.

exasperating defect. The Blake transmitter, instead of being placed flush with the front of the bell box was set in so far as to lead to much vexation of spirit, through the subscriber's forehead coming in contact with the bell box.

In referring to the early telephone equipment, Mr. B. E. Sunny stated, in 1887, that

the field for improvement in the construction of subscribers' apparatus is a particularly broad one. The entire outfit is crude and defective, and it represents a smaller growth towards perfection than anything else that we have in the service. The magneto as constructed to-day (1887) is a cheap looking affair, except the new Gilliland, and they are all more or less unreliable, while after ten years' experience we ought to have an instrument that would look in keeping with the furnishings of the finest residence or office, and that would be free from electrical defects.

The parent Bell company perceived the wisdom of standardizing its equipment long before it decided on uniformity in line construction. With that end in view, as well as 'to obtain a permanent interest in the manufacture of telephones and switchboards,' in 1881, it purchased the factory and business of Charles Williams, Jr., of Boston, where Graham Bell had carried on his early experiments, and where the first several thousand telephones were made. It also bought an interest in the Western Electric Manufacturing Company of Chicago and merged the two into one organization, which, under the later name of Western Electric Company, has grown to be the largest industrial plant of its kind in the world, occupying more than seventy acres of floor space, employing more than twenty-five thousand persons, and with sales exceeding $70,000,000 annually.

In connection with the early selection of a permanent manufacturer, Mr. T. B. Doolittle, formerly an experienced manufacturer of metal goods, makes the following statement that indicates how easily the city of Bridgeport, Connecticut, might possibly have had a manufacturing establishment similar to the Western Electric Company:

> My interest in mechanics and manufacture led me to spend much time in the factory of Mr. Charles Williams, Jr., in 1877–78, and to offer suggestions regarding the details of construction. For example, I substituted the bell 'struck up' from sheet metal in place of the cast and turned bell, thus reducing the cost from about fifty cents to about five cents. I also brought about a large reduction in the cost of the cabinet work used in the manufacture of switchboards and telephone apparatus. These large savings attracted the attention of the management of the parent company, and I was authorized to find a manufacturer having a factory properly equipped and enter into negotiations for the manufacture of telephone equipment. I visited several factories in Connecticut, among others the Wheeler & Wilson Sewing Machine Company, at Bridgeport, but found none who were willing to enter into such a hazardous undertaking and one that promised so little future growth. I endeavored to convince Mr. Wheeler that the future was rich in promise, and that his company would not only become a licensed manufacturer, but, in all probability the permanent manufacturer. But though trade was slack, he would not entertain my proposition.

SIGHT AND SEEING IN ANCIENT TIMES

By Dr. Charles William Super
Athens, O.

When we pass along the streets of our cities and large towns and observe the number of persons between the ages of twenty and forty who wear spectacles; or again, if we inspect the eyesight of the children of our public schools and of the young people in our colleges, we find that a large proportion of the present generation is afflicted with visual organs more or less defective. More than this, there is hardly a person over fifty who does not use some sort of artificial aid to sight. In the German universities the situation is still worse. There, apparently, almost one half of the students wear eye-glasses. England furnishes a marked contrast; spectacles on the eyes of young men and young women are far less common. The chief reason doubtless is the fondness of both sexes for outdoor life. It is highly probable that our somewhat abnormal eyesight is chiefly due to the abnormal conditions under which we live. The epithet *abnormal* is of course to be understood in a relative sense; it is not strictly applicable to a highly developed stage of civilization. It can not properly be said that the conditions under which the Papuans or the Bushmen live are more natural than those of the residents of London or New York. Each generation is, in a sense, weaker but also wiser; what is lost in one direction is more than made up in another. Still, the injudicious use of the eyes in artificial light and a short range of vision seem to be inevitably imposed upon the dwellers in cities. It is a well-established fact in hygiene that any bodily organ is strengthened by the wise use of it. This being the case, it follows that persons who spend much of their time out-of-doors and in looking at objects afar off, or who use their eyes but little after nightfall, will retain their sight unimpaired much longer than do most people of the present day. On the other hand, failing vision is the natural concomitant of advancing age, so that the number of persons beyond sixty who see clearly with the naked eye is exceedingly small and probably was never very large.

Moreover, the human eye is said to be a rather ill-contrived piece of mechanism. A celebrated German physicist is reported to have remarked that if an artisan were to make for him a piece of apparatus so poorly adapted to its purpose he would not accept it. Biographers have, however, preserved the names of a considerable number of persons from the remote and more recent past whose mental faculties were unimpaired at fourscore and beyond, though it is not often that this could be affirmed of their sight. The last chapter of Deuteronomy informs us that Moses was 'an hundred and twenty years old; his eye was not dim nor his natural force abated.' There is nothing incredible in this record, for similar instances are not very rare. A colored woman died in Philadelphia in January, 1906, who seemed to have pretty clear recollections of Washington at Valley Forge. Her friends claimed for her the age of one hundred and thirty-five. A writer in a recent issue of the *Monthly Review* mentions a number of Kaffirs still living in 1885 who professed to have taken part in a battle in 1818. Burton made the acquaintance of a chief, whom he described in 1857 as a very old man; but eighteen years later Cameron found him still ruling his people and very little changed in appearance. While Humboldt was in Lima an Indian died there at the age of one hundred and forty-three. "Blindness overtook him at the age of one hundred and thirty, but till that misfortune he used to walk three or four leagues daily." He also declares that during his five years' residence in Mexico and South America he saw no person afflicted with bodily disease or even with squinting. Tschudi says that one hundred and thirty years 'with unimpaired faculties' is not at all uncommon in Peru. These references are doubtless to natives; and what is true of the so-called lower races does not necessarily hold good of the more advanced peoples. Among the more recent cases that are thoroughly authenticated are the Hon. David Work, of Fredericton, N. B., who died in 1905, nearly one hundred and two years old. He was a man of mark in his community, and mentally and physically sound almost to the end. The celebrated French chemist, Chevreul, who died in Paris in 1889, was about a year older. John Wesley at eighty-five writes that he is "not quite so agile as he was in times past and his sight is a little decayed." Most persons, unless their observations have been very limited, have met individuals who lived close upon fivescore years or even beyond. Several Roman writers likewise give 120 years as the utmost limit of human life. Sight is preeminently the civilizing sense; upon it all progress depends, or, as Oken expresses it, "Sight is the light sense. Through it we become acquainted with universal relations, this being *reason*. Without the eye there would be no reason." The same thought is expressed in the Sermon on the Mount: "The lamp of the body is the eye. If your eye is unclouded your whole body will be lighted up; but if your eye be diseased your whole body will be dark." Not only painting, sculpture and architecture are dependent upon sight, but language also as soon as it becomes the transmitter of experience, whether inner or outer, from age to age. Those peoples that never cultivate speech beyond the point where it is perceived by the ear alone, never advance farther than the primitive stage. But as soon as speech becomes cognizable by the sight, it can be employed to fix the experience and the accumulated knowledge of each generation. It is by means of our eyesight that we are able to learn the thoughts and, to some extent, the feelings of the people of the most distant ages and the most remote regions, almost as well as those of our intimate friends. Yet when we remember that man has left intelligible traces upon the earth, dating back at least seven thousand years, and compare their testimony with the world, say three hundred years ago, we are not conscious of a great advance either intellectually or socially. It is evident, therefore, that important as sight is to man, something more is needed to make him progressive. As soon as the mind becomes fossilized by tradition all advance ceases. If, on the other hand, we compare the world about A.D. 1600 with its condition at the present day, we are constrained to marvel at the advance that has been made. In fact it is not putting the case too strong to say that if by progress we mean man's power over matter, it has been greater during the last fifty years than during all the preceding time of his abode upon the earth. No more striking example of the stationary condition of mankind in certain relations exists than that furnished by artificial lighting. The situation in 1800 was virtually the same that had existed from the earliest times. Torches were used out-of-doors and lamps indoors. Many of the latter found in Grecian and Roman tombs served their purpose just as well as some of those used within the memory of men now living. Friction matches did not become general until about the middle of the last century. It is sometimes said in a tone of deprecation that as the realm of science increases that of poetry diminishes. Yet the fact is that the appreciation of the beauties of natural scenery has advanced with the careful study of nature. There may not be a realized connection, for poets are rarely scientists; albeit both have often been equally close observers, even if not found in each other's company or united in the same person. Few men have written more appreciatively or more sympathetically of the beauty and grandeur of natural scenery than geologists not a few; and geology is among the most modern of the sciences. The botanist who sees vegetation not only with his corporeal eye, but with his mind as well, derives a keener enjoyment from the beauties of vegetable life than does he who can not see beneath the surface; who has no conception of the forces that make plant life what it is.

To the ancients, especially to the Greeks, sea and stream, forest and field, mountain and moorland, were peopled with animate beings, it is true, and their imaginations seem to have sported in a region that is virtually closed to us moderns. On the other hand, while these beings were objects of interest they were also sources of terror; they were quite as often the doers of mischief as the bringers of blessings. Storms and lightning, floods and volcanic eruptions, are still natural phenomena to be feared, but they are no longer looked upon with superstitious dread as something to which man must submit with a blind and unreasoning fatalism. Their devastations can in some measure be guarded against and mitigated. Such lines as the following from Bryant could not have been written by a Greek poet since they express sentiments to which entire antiquity was a stranger:

> **Look on this beautiful world and read the truth**
> **On her fair page; see, every season brings**
> **New change to her, of everlasting youth;**
> **Still the green soil with living joyous things**
> **Swarms; the wide air is full of joyous wings,**
> **And myriads still are happy in the sleep**
> **Of oean's azure gulfs, and where he flings**
> **The restless surge, eternal love doth keep,**
> **In his complacent arms, the earth, the air, the deep.**

The same affirmation may be made of Bryant's 'To a Cloud,' 'To a Waterfowl,' and other of his poems not a few; or of Shelley's 'Cloud' or the 'Skylark,' and many more. In Plato's Phædrus, one of the characters says: "Here is this lofty and spreading plane-tree, and the agnus castus high and clustering, and the fullest blossom and the greatest fragrance; and the stream which flows beneath the plane-tree is deliciously cool to the feet. . . . How delightful is the breeze; and there is a sound in the air shrill and summer-like which makes answer to the cicadæ." Here we have, it is true, a flash of the love of nature. But some centuries later Plutarch refers to this passage as rather silly. While we are not sure that he is uttering his own sentiments, such seems to be the case.

In reading Greek authors we are perpetually confronted by the fact that they were acute thinkers and poor observers. They used their minds a great deal more than their senses. When they undertake to explain phenomena, they usually try to think out an explanation instead of first taking care that the phenomena in question have been correctly observed and registered. As for the Romans, not one of them ever had an original idea except on matters that could be turned to practical use.

Tacitus, for example, says that north of the Orkneys the waters are so sluggish, according to report, that they yield with difficulty to the oar and are not even raised by the wind. He then proceeds to assign as a probable reason that the extreme depth of the water makes it difficult to set in motion. Equally lucid is his explanation of the long days in the same region. Believing that night is produced by shadow, he tells us that owing to the flatness of the earth the darkness does not rise sufficiently high to reach the sky and the stars. He did not know that the nights are equally long. The Greek original from which our word eclipse is derived means a 'leaving' or 'departure.' So Herodotus, when speaking of an eclipse, says, the sun "Suddenly quitted his seat in the heavens and disappeared, though there were no clouds in sight, but the sky was clear and serene." This is quite equal to an argument I once heard upon the question whether the moon is inhabited. The rustic logician declared that such could not be the case because the people would have no place to go when it began to decrease. What an immense amount of speculation and calculation the Ptolemaic system made for the astronomers! The philosophers all agreed with Pliny that 'with the mind we see, with the mind we discriminate'; but unfortunately they too often forgot that the mind can not discriminate unless the senses have correctly furnished the facts. So far as sight is concerned, this is strikingly exemplified in all the work of the well-known mathematician, Euclid. As he knew nothing about refraction and had no rational theory of light, he had recourse to philosophy to provide him with a basis for his work on optics, but which is really a treatise on perspective. So far as is now known, the first man who made a study of refraction was Posidonius, who lived nearly two centuries after the father of geometry. He illustrated the principle by the familiar experiment of placing a coin on the bottom of an empty vessel in such a way that it was not visible because of the intervening rim, then bringing it into sight by filling the vessel with water.

The ancients were almost entirely without apparatus and had no instruments of precision; in fact, very few of them had any interest in the mechanic arts. Though Thales foretold an eclipse of the sun as early as B.C. 600, neither the Greeks nor the Romans had any way of measuring time that was even approximately accurate. Under the republic the normal Roman year contained only three hundred and fifty-five days. Julius Cæsar very nearly corrected the error, although in the time of Pope Gregory XIII., the year had become eleven days too long. It has ceased to be a matter of controversy whether the christian era is four years too short. There is hardly any doubt that the authors of the Homeric Poems had a very undeveloped color-sense. It is highly probable that two or three millenniums ago the countries about the Midland Sea, especially the Ægean, displayed to the appreciative beholder many glorious landscapes which the destruction of the forests and the drying up of the perennial streams have completely obliterated. Not a few streams that formerly flowed all the year round have become temporary torrents, more baneful than beneficent in their effects or beautiful to behold. Many hills that were once covered with natural vegetation now present a parched and barren appearance. In the Homeric Poems we find epithets not a few that felicitously describe natural objects, or at least characterize them, but they are the result of a happy instinct rather than a careful observation. In the long 'Hymn to Demeter,' not many lines are given to an enumeration of the flowers that spring so profusely from the bosom of the earth. The treatment of the subject is perfunctory and superficial. In the much shorter 'Hymn to the Earth, the Mother of All,' flowers are barely mentioned and not particularized. In the brilliant description of the gardens of Alkinous, the author of the 'Odyssey' tells us there "grow tall trees blooming, pear-trees, and pomegranates, and apple-trees with bright fruit, and sweet figs, and olives and their blossoms. Some of the fruit is always ripening, yet there is a constant bloom on the trees and much unripe fruit. There too, skirting the farthest line, are all manner of garden-beds, that are perpetually fresh." We have here a sort of combination of orchard and vegetable garden, for plainly the writer had in mind utility rather than beauty. At any rate there is nothing in this quotation, in which the author had literally sent his imagination on its loftiest flights, to indicate that he knew cultivated flowers. The same may be said of 'Calypso's Isle.' The Greeks considered crowns of flowers or leaves of some kind indispensable at every banquet and revel. Anacreon, the prince of voluptuaries, frequently refers to this well-known custom. The material of which the wreath was made does not seem to have been regarded as of primary importance. The symbol only, not the substance, was essential. According to Xenophon, when some of the ten thousand in Armenia in the depth of winter were invited to a feast by one of the native chiefs, the revelers crowned themselves with hay. The will did duty for the deed. This story reminds one of the Arabs, who are punctilious in performing the stated ablutions enjoined by the Koran. But as water is sometimes too precious to be wasted in this way, they use sand, which, mixed with a liberal amount of credulity, is to the faithful equally efficacious. The extracts from Homer recall the so-called hanging gardens of Babylon constructed for Semiramis more than two thousand years before Christ. These constituted a park built on an artificial elevation, so that the epithet usually applied to them would be equally suitable to the grounds at Versailles or the Buttes Chaumont in Paris—all hung on the ground. The Persian monarchs and noblemen maintained extensive pleasure-grounds, in which great quantities of game were enclosed. It is from their designation of these parks that we get our word Paradise. It comes to us from the Greek, and is found in nearly all the modern European languages. The general opinion, however, is that the first parks, in the modern sense of the term, were the work of the Roman emperors.

Homer has no word for 'color' nor for any of the primary colors. In like manner the term usually translated 'black' is very indefinite. It is used of the bronzed complexion of Ulysses and of his henchman, Eurybates; of the ripe grape; of beans; of wine, and of the storm cloud. We moderns would say that it is strictly applicable in the last case only; certainly the difference between the hue of the storm cloud and the darkest complexion of a white man is very marked. Of Agamemnon it is said that he 'stood weeping like unto a fountain of dark water that from a beetling cliff poureth down its black stream.' In the 'Odyssey' it is said of Ulysses that 'Athena shed great beauty from his head downwards . . . and from his head caused deep curling locks to flow like the hyacinth flower.' This comparison, which is made twice, is absolutely incomprehensible to us, if it has reference to color. It is also noteworthy that the epithet which is variously translated 'golden,' 'fair,' 'blond' is so applied to most of the Greek heroes and to horses. Evidently the author of the Homeric poems believed that the Greek nobles did not have the usual dark complexion of the southern races. Be that as it may, we can not resist the conviction that in primitive times the various shades of color that made the same general impression on the sight were named alike. There was hardly any discrimination of the sensations. Homer's usual method of designation of colors is by comparison; hence such words as 'steel-blue,' 'saffron-colored,' 'blood-red,' 'vermilion-cheeked' are common. A table has 'dark-blue' feet; the same adjective is also applied to the prow of a ship, to hair, to a horse's mane and to the eye. Fear is said to be *chloros* (of a greenish yellow). Still, this is hardly more curious or more inexact than Shakspere's 'green-eyed monster,' and the current phrase 'to turn green with envy.' It is not easy to discover the underlying idea. The same epithet is translated 'blood-red' when applied to a serpent and 'tawny' when used of the color of jackals. Though the Homeric Greeks were in some respects a good deal more advanced than our Indians, in the appreciation of the beauties of nature, they were not very wide apart. Henry T. Finck, in his 'Primitive Love,' adduces plenty of evidence to prove that the "Indians have no conception of the romantic side of nature—of scenery for its own sake. To them a tree is simply a grouse-perch, or a source of firewood; a lake, a fish-pond; a mountain, the dreaded abode of evil spirits." He assures us that the real Indian and the Hiawatha Indian are just as much alike as fact and fancy. In Homer's circle there was no interest in flowers or blossoms and no mention is made of garlands, although they played so important a part in the social life of the later Greeks. When flowers are mentioned at all it is almost solely on account of their color, which serves as a basis of comparison. One exception that I recall is the passage where one of Priam's sons is smitten with an arrow so that: "Even as a garden poppy droopeth its head aside, being heavy with fruit and the showers of spring; so bowed he his head aside laden with his helm." The Homeric Poems are supremely important for the insight they afford into the early civilization of the people which they portray, but they contain a great deal that is repulsive to our far more refined sensibilities. Empedocles speaks of but four colors: white, black, red and pale green. It is hard to believe that the age in which this philosopher lived knew at most only two prismatic colors. It is more probable that he regarded green and blue, and perhaps some other colors, as derivatives from these and therefore not entitled to separate enumeration. According to Democritus, there are but four primitive colors, from which all others are formed by combination. He seems to have regarded blue and green as variants of black. Aristotle thought there were only two primitive colors: light or white and black or dark, and that all others were produced by a mixture of these. Wide as this is from the mark, it shows a tendency to simplify natural phenomena, though it would doubtless be going too far to suspect in this belief an inkling of the composition of light. In the Old Testament four prismatic colors are mentioned, three of them very often and yellow four times, three times in Leviticus and once in the Psalms. In the former, it is used of hair; in the latter, of gold. As the Hebrews were surrounded by nations that had made great advances in technical skill, it is probable likewise that all of them had made greater advances in the discrimination of colors than the Greeks.

The fact that the ancients habitually speak of only four colors is almost proof positive that they did not discriminate more. In addition to the evidence already cited, there is to be added that of painting. What is known of the art of Polygnotus, the earliest of the distinguished painters of antiquity and a contemporary of Pericles, leads to the conclusion that he used no greater number, according to the ideas of his time. Like all early painters he worked on terra-cotta vases and on walls, not on canvas. It seems highly probable that throughout antiquity no distinction was made between orange and yellow, nor between indigo and blue, nor between the darker colors that shade into black. Many of the lower races, both at home and abroad, share this defect. Both have also the same liking for what is gaudy and striking. It is probable that the fondness for 'loud' colors is a species of survival that may be studied in children and in persons that are color-blind. The latter defect is a species of arrested development, and being an organic defect can not be overcome. On the other hand, some primitive races are reported to exhibit a very acute color-sense. This mental condition has likewise its analogy among children, some of whom are indifferent to colors, while in others the color-sense shows itself very early. At any rate, modern analogies will not enable us to decide the question for or against any people of antiquity. Two theories have long been held to account for the poverty of terms to designate colors in remote times. The one most in harmony with the evolution hypothesis is that the color-sense has followed the general law of development; the other, that primitive races perceive colors as clearly as we do, but that their languages lack words to designate minor differences. Color-blindness has no connection with mental power in general. It is well known that the celebrated physicist, John Dalton, was not capable of distinguishing more than three colors. Many similar cases are on record. This defect has become known as daltonism or achromatopsia. A more correctly constructed compound would be chromatuphlosis. However, technical terms often lead the philologist to express the same opinion of them that the devil is said to have used of the Ten Commandments, "They are a queer lot." In the language of the Psalmist, "They are fearfully and wonderfully made." Generally speaking, animals make less use of sight than man; all those that have been domesticated select their food by the sense of smell and not by sight. The test may be readily made with blind horses, which are unfortunately not as rare as they ought to be. Birds, on the other hand, depend wholly on the sense of sight, which is remarkably acute.[1] In ancient accounts of battles, sieges and pestilence, those gruesome birds that live on corpses are never absent. It may be taken for granted that the problem, How do we see? exercised the ingenuity of the ancient thinkers a great deal. It need not surprise us that they were wide of the mark, seeing that there is as yet no universally accepted theory of vision. But the moderns have learned that color is subjective, whereas the ancients regarded it as objective. Lucretius, who follows the teachings of some of the Greek philosophers, probably of Empedocles, affirms that very thin films are detached from the visible object and impinge upon the eye to produce sight. Aristotle was convinced that there must be some medium between the organ of sight and the object seen by which the sight-process is mediated. Lucretius says that persons afflicted with jaundice see everything yellow because so many atoms of that color fill the orb of sight. He compares the casting away of films or effigies to the cicada that casts off its tunic, or the snake that sheds its glossy vesture and to fire that emits smoke. Much later Locke says: "Since the extension, figure, number and motion of bodies of an observable bigness may be perceived at a distance by the sight, it is evident that some singly imperceptible bodies must come from them to the eye." Lucretius seems to have observed natural phenomena with unusual care for a Roman, but it was rather their more violent aspects, such as thunder and lightning, earthquakes and waterspouts and floods. The phenomena of rain, hail and snow could of course not escape his attention. It has been shown above that the ancients, particularly the Greeks, had a very defective perception of colors and that they had very poor eyes for the beauties of nature as displayed in scenery. It may be interesting to trace briefly the growth of this last sentiment, since it is one of the latest phases of evolution. The Greeks were eminently a social people. They laid

[1] I recently came across the following—how much truth there is in it I do not know: "Red will annoy a turkey-cock as much as a bull, but a sparrow will not let it disturb its mind. But if one shakes a blue rag in front of a caged sparrow's eyes, he will go frantic with disgust. Sparrows, and linnets too, will refuse food offered to them on a piece of blue paper, and dislike the appearance of any one wearing a blue dress. Medium light blue affects them most, but blue serge they scarcely mind at all. Thrushes and blackbirds object to yellow, but will use red or blue dried grasses left about their haunts to build the outer layers of their nests. Yellow grasses they let alone."

great stress upon that urbanity which is acquired only by long association of man with man. Greek pedagogy insists that education shall above all things make the gentleman. Greek thinkers were far more interested in their fellow men than in their irrational companions or in the silent creation. It is true Theocritus, and the much later Dio, praise country life, but they lived in an age that was preeminently one of books. They commend the simple and unsophisticated manners of those who keep aloof from the haunts of men more than they express delight in their rustic surroundings. They do not like nature so much as they dislike man. Among the Romans, Virgil and Horace follow the same course. They either never leave the city or they stay within easy reach of it. They do as did the usurer whom the latter portrays in his much-read and often-translated second Epode. After enumerating the delights of country life and the various vexations of those who have much to do with men, he ends just where he began—by staying in the city. This praise of rural life reads as if written by one who knew but little about it. We find much the same thing in Germany in Gessner's writings and in England in the age of Anne.

Pope declares:

> Happy the man whose wish and care
> A few paternal acres bound;
> Content to breathe his native air
> On his own ground.

Yet he never went farther from London than Virgil or Horace from Rome. We get curious glimpses into the vagaries of taste when we trace even in the barest outline the manifestations of what was supposed to be a love of nature. Virgil's Pastoral poems seem to have been the original inspiration. We can follow their influence in almost every country of Europe from the fifteenth to the seventeenth century, and, to some extent, in the eighteenth. Even the horticultural art was made subservient to this fantastic taste of which Lenotre was the chief apostle. Trees and shrubbery were clipped and trained into artificial forms, and flowers were planted according to geometrical figures. The aristocracy professed a love for nature, but it was nature of a very unnatural sort. It is not until we come to Bloomfield and Crabbe, but especially to Wordsworth, that we find nature and the unsophisticated man receiving a genuine poetical treatment by persons who knew both at first hand and studied them with genuine sympathy. Walter Scott was likewise an ardent lover of nature and of natural scenery. Both his poetry and his prose are evidence. His novels contain many elaborate descriptions of scenery that bear the stamp of verisimilitude. They are the work of a constructive imagination of the highest order. If Xenophon had had an eye for the beauties of mountain and plain, of forest and stream, he would have left upon record his impressions of them rather than the numerous and long speeches he has handed down to posterity, made for the most part 'out of his own head.' If it be alleged in extenuation that the circumstances under which his notes were taken were ill suited to the careful study of external nature, it is to be said in reply that he observed and recorded what most interested him. His itinerary is so inaccurately, or at least so sparingly, marked that no modern explorer has been able to follow or trace it. In view of the fact that the ancients did not receive as much pleasure from the contemplation of scenery as we moderns, it is probable that they did not regard blindness or failing sight as a very serious misfortune. In Schiller's Tell we have a notable passage describing the frightful misfortune of blindness:

> Oh! 'tis a noble gift of Heaven,
> The gift of sight, each being lives on light,
> And all creation feels its gladding power!
> The plants themselves turn joyfull to the light:
> To die—is nothing—nothing! but to live,
> And not to see—is misery indeed!

The Greeks believed that the power of internal vision was enhanced by lack of bodily sight. This belief was in accordance with the law of compensation held by them. Fortune, good or ill, is always outweighed by its opposite. 'The blind old man of Scio's rocky isle' was supposed to have been blind because his intellectual insight was preternaturally acute and accurate. Tiresias, the most famous seer in Greek legend, is always spoken of as blind. We do not know whether this preternatural acumen was the result of his want of sight or whether the latter was a condition precedent to the former. One of the favorite characters of Greek mythology was Œdipus, spending the sunset of his life in dignified retirement near Athens under the care of his daughter Antigone. In early years he had blinded himself after discovering that he had unwittingly been guilty of incest. The Greeks did but little by artificial light. They were early risers and all reputable people were supposed to retire early. Plato, in his Laws, says the master and mistress of the household should be the first to rise in the morning in order to show a good example to the other members. He further says: "Magistrates who keep awake at night are terrible to the bad whether enemies or citizens and are honored and revered by the temperate, and are useful to themselves." Throughout the entire ancient, medieval and modern world, until within comparatively recent times, the badly lighted or totally dark streets made it a matter of prudence for honest people to go abroad as little as possible after nightfall, especially if they carried or were supposed to carry articles of value. The comparative sameness in the style of clothing gave the footpad the opportunity to replenish his wardrobe at the expense of his fellow without saying, 'By your leave.' We are not told that the man who went down to Jericho was attacked in the night, but we are informed that he was stripped. That the ancients placed a much higher value on worn garments than is done by the moderns is shown by the statement that the soldiers who kept guard over the body of Christ on the cross cast lots for his raiment. This was the custom at the execution of malefactors.

It is curious that the free Greeks were in the habit of rising early, for, owing to the abundance of slaves, most of them had little compulsory work to perform except when on military expeditions. A law of Solon prohibited teachers from opening school before sunrise or holding it after sunset. To the casual reader this may sound ridiculous. But to many of our older college graduates, it will occur that they were required to attend prayers so early in the morning that they had to be conducted by lamp or candle. An acquaintance of mine who lived near a certain college used to relate that he well remembered hearing young men pass his house in the dark of the morning who, while completing the process of dressing, interspersed the performance with occasional expressions not suitable for ears polite. The mood in which such persons reached their destination was evidently not well suited to the spirit of devotion which those early exercises were supposed to foster.

Many people believe, because they have read in books, that the sight of the Indians was extraordinarily keen, and that they were able to descry objects at a greater distance than was possible for white men. This is an error, if the assertion is to be taken without qualification. All savages have eyes trained to see those things that are necessary to their preservation—game and enemies. Their sight is not by nature more acute than that of the white man, but in some respects it was better trained. The whites who lived among the Indians and were compelled to defend themselves against their enemies saw just as far as their enemies. It may be affirmed as a general principle that there is nothing a civilized man can not do better than a savage. The latter uses his reason to aid his instinct; the former makes his instinct subservient to his reason. It is well known that sailors are able to discern objects at sea at a greater distance than landsmen, but we have to do here with a faculty that any one can acquire. The Indians did just what the whites who lived among them did who subsisted on game and were obliged to be on the constant lookout for enemies. Both had acquired not merely the power to discern objects, but also training in the interpretation of the signification of those objects that came within visible range. It is probable, for reasons given above, that not only the Indians as well as all tribes living on the same social level, but also the backwoodsmen, retained their sight to a more advanced age than is now generally the case; but that the eye of the former was naturally more powerful than that of the present generation or that of men in general is unsupported by trustworthy evidence. There is no doubt that a child born with normal eyes in one of our large cities can see objects just as far off and define them just as accurately with proper training as a person who never saw a dozen houses together. It is well known, too, that what are sometimes called the lower senses, touch, taste and smell, are often of extraordinary acuteness in civilized man as the result of training. If, therefore, any of the senses of our urban population is feebler than that of the dwellers in the rural districts, it is not due to an inherent weakness, but to improper or injudicious use.

Since it is evident that the ancients, particularly the Greeks, looked upon the external world with emotions very different from the moderns, let us next inquire what means they possessed, if any, for strengthening the sight or aiding defective vision. The problem has been a good deal discussed. Those who believe that some sort of apparatus corresponding to modern eye-glasses has been in use from almost time immemorial rely chiefly upon inference, since hardly any direct evidence is forthcoming. It is held by some investigators that the very large number of seal rings and seal cylinders, both intaglios and cameos, dating from the remotest times found in the Babylonian tombs, must be accepted as proof positive that the art of cutting the hardest precious and other stones was a regular business in that part of the world, and that this could not have been carried on without some kind of magnifying lenses. That work of this sort could be performed only by persons of exceptionally keen eyesight is beyond question: the inference drawn from modern experience is logical. Yet in the absence of objects which might reasonably be expected to be forthcoming, we are constrained to render the verdict 'not proven.' So far as we have direct testimony, it is all adverse, if the expression be admissible. It is generally held that the first mention of magnifying glasses is found in an Arab writer of the eleventh century. Roger Bacon speaks of glasses that correct refraction. The epitaph of a certain Salvinus Armatus in Florence names him as the inventor of spectacles, although it is also said of the monk Alexander of Spina, that he made use of eyeglasses. In the year 1488 makers of spectacles are mentioned in Nuremberg. There is a passage in Scott's 'Quentin Durward' that represents Lord Crawford with spectacles on his nose, and the remark is added that the invention was recent. That artificial aids to sight are modern is also rendered probable from the lack of a word inherited from antiquity to designate the apparatus. The English word 'spectacle' is still used in a sense that differs but little from its Latin parent: it is something to look at, a stage-play, then the theater itself. But the earliest English 'spectacle' is used for spy-glass. It is thence probable that our plural 'spectacles' originally meant a pair of spy-glasses, a sort of anticipated binocular. The French *spectacle* still has its original Latin meaning, the form of the word being but slightly changed. On the other hand, in the German and Scandinavian languages, *Spektakel* is equivalent to what we call a 'rumpus.' But

Brille (spectacles) is from beryllus, the Latin name of a transparent stone. The French *besicles* also point to beryl. *Bericle* is an earlier form of *besicle* for 'besiculum,' a little beryl. In some of the French dialects the first syllable *ber-* is still preserved, but the Parisian word for spectacles is *besicles,* in which the original *r* has been changed to *s,* according to a phonetic law traceable in other words also. The Spaniards, Italians and Russians have each a native word to designate this article of common use.

There is a passage in Pliny that is usually cited as evidence that something akin to spectacles must have been in use at least in his time. He relates that the Emperor Nero used a precious stone which he calls 'smaragdus,' generally translated 'emerald,' through which he was accustomed to gaze on the gladiatorial combats; or rather, this is what he seems to say. There is, however, little doubt that Dr. Magnus, the latest author to examine the passage critically, is right in holding that it means no more than that the emperor was in the habit of gazing upon an emerald which he used to carry with him for the purpose of resting his eyes when they became tired looking upon shows that were interesting to him. This view is rendered the more probable from the belief of antiquity that green has a restful effect upon the eyesight.

Contrivances for bringing the rays of the sun to a focus in order to produce combustion have been employed almost from time immemorial. A curious proposal bearing on this point is made by Aristophanes in his comedy of the 'Clouds.' Strepsiades, the hero of the play, is greatly harassed with debts and has not the wherewithal to pay. He therefore proposes to his master to get a stone at some chemist's shop of the kind with which they kindle fire, and when the clerk is entering the suit, to stand at some distance and melt it out. As the writing tablets then in use were probably thin boards covered with a still thinner coating of wax on which the writing was done with a pointed instrument, it would not require great heat to effect the purpose. Besides, if, as seems to have been the case and custom, burning-glasses were used to kindle fires, they must have been of considerable size even in a country like Greece where the sun shines very hot most of the year. Moreover, we are told, they were kept in the chemists' shops for this purpose. If by any mishap the sacred fire watched over by the Vestal Virgins in Rome went out, it was rekindled by means of a burning-glass. Polybius, when speaking of the siege of Syracuse by the Romans, B.C. 214, relates that they were unable to take it from the side of the sea because of the engines employed against them by Archimedes, unquestionably the greatest mechanician of the ancient world. Says he: "So true is it that one man and one intellect properly qualified for the particular undertaking is a host in himself and of wonderful efficacy." The Romans were confident that they could take the city 'if one old man could be got rid of.' He might have added with equal truth that when a man appears in a world wholly unprepared to comprehend him, not only are his thoughts neglected, but his discoveries forgotten. The story that Archimedes set the ships of the Romans on fire by means of burning-glasses is not found in any author who lived near his time. Moreover, the captains of the vessels would hardly be so obliging as to hold their vessels stationary in order that the old philosopher might work his will on them. Yet the marvelous feats he accomplished on the same occasion and vouched for by credible witnesses are scarcely less incredible. It may be accepted as certain that Archimedes produced wonderful effects by means of his lenses, whether they were made of glass or of some other material. That the ancients as late as the age of Plutarch knew nothing of spectacles is clear from the negative testimony of this writer, whose works might be superscribed 'Concerning all Things and Some Others.' In one of his table talks he tries to explain why old people, when reading, hold the book at some distance from the eyes. He finds the reason to lie in Plato's theory of vision, which he also holds. This philosopher maintained, in common with almost all the thinkers of antiquity, that sight is produced by a sort of fluid substance passing from the visible object to the eye, somewhat in the shape of a cone, the eye being the apex. When the organ becomes weakened by age this attenuated substance is too intense to permit normal vision; so in order to weaken it the object must be held farther away. He finds a confirmation of this theory in the habits of those animals that seek their prey by night when their sight is most acute. The fluid emanating from the object is too strong to be properly commingled with the power of vision, as he expresses it, possessed by these animals, but is so weakened and diluted by the surrounding darkness as to enable them to see at their best. This may seem to us very puerile; it ceases to be so when we remember that to this day no one has been able to answer the question, How do we see?

Though the art of making glass of certain kinds is very old, spectacles had to wait on the discovery or invention of some method that would produce it perfectly transparent. Specimens of glass have been found in the Egyptian tombs that are more than four thousand years old, and glass bottles are represented on tombs at least fifteen hundred years earlier. In Mesopotamia the art of making glass has been traced for at least two thousand years B. C. But all the glass of antiquity was of inferior quality and was almost useless for purposes where the rays of light were to be transmitted unbroken and with undiminished energy. Mirrors were also made in Egypt thousands of years before the christian era. The materials used were obsidian, metal, zinc and silver. Glass mirrors are mentioned by Pliny, but as they were neither perfectly plane nor foliated they gave back a very imperfect image and were not much esteemed. The word translated 'glass' in King James's version is not as clear as in some of the later renderings. The passage in the First Epistle to the Corinthians if read: "As yet we see things dimly, reflected as in a mirror, but then face to face," makes the sense plain. As looking-glasses, to use this term by anticipation, were generally made of steel or some other metal, they readily became tarnished, even when of the best quality; hence the man who beheld his face 'in a glass' rarely got a distinct image, and thus would readily forget the lineaments of his countenance. That window glass, such as is now in common use, was slow to gain currency is shown by the little panes in many old buildings in Europe. They are usually round or nearly so, and so small that one of them can easily be held between the tips of the fingers and the thumb. That this form of window glass first came into vogue in Germany is evident from the name disk (Scheibe) by which a pane of glass is still designated, no matter what its shape.

That ancient customs are still practised by primitive tribes is interestingly shown by the two following incidents. In the Iliad we are told that when Asklepias 'saw the wound where the bitter arrow had lighted he sucked out the blood,' and so forth. In his recent work on the Australian aborigines, John Mathew informs the reader that the doctor or sacred man made a practise of sucking the part affected. He then proceeds: "There seems to be some efficacy in the sucking, for a friend of mine who was suffering severely from an inveterate, inflamed eye allowed a black 'doctor' to mouth the eyeball, and the result of the treatment was immediate relief and speedy cure." A further parallelism between the rise and practise of the healing art and the priestly class, although in Greece the connection was less close than elsewhere and did not long continue, is shown by this extract.

The reading habit is essentially modern and may be said to date from the rise of periodicals, comparatively few of which are more than half a century old. The invention of spectacles and that of printing were very nearly coeval. Until that date literary instruction was largely a matter of dictation, repetition and memorizing, as is still the case in many parts of the world. Among the ancient Greeks and Romans the memory was trained to a far greater extent than with us. In the literature of the former there is constantly evident a sort of distrust of the written page. It could not reflect the vivifying power of the living voice. It seems to have been a common thing for Greek youths to learn Homer by heart, huge as the task would be to us. Knowledge was to be elicited by discussion, by the dialectic method, by question and answer. Intellectual training was almost exclusively rhetorical. Taking into consideration, therefore, the fact that eyes were not needed for the manufacture and use of instruments of precision and that the printed page did not exist, we can easily understand that spectacles were not greatly missed.

THE CLASSIFICATION OF THE ARTS

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THE conventional classification of the arts into useful, mechanic or industrial, and liberal, polite or fine is unscientific. It will not stand before even a superficial examination. Fine and useful are by no means mutually exclusive terms. The fine arts are useful, and the useful arts should be fine. The art that paints a picture or chisels a statue satisfies the desire for beauty. It is, therefore, useful for the same reason that cooking or farming or making shoes is useful. All that the word useful implies is satisfaction of desire, and this is the object of all the arts. On the other hand, the word fine, as applied to art, does not signify the absence of utility, but merely that the art has been brought to a certain degree of perfection (polite-polished), and that its practise is associated with gentility. There is no inherent reason why a useful art may not become a fine art. Obviously, then, the division of the arts into fine and useful is not dichotomous. One might as well divide the sciences into practical and interesting.

But are not the fine arts to be distinguished from the useful arts on the ground that the former involve the use of the imagination and the realization of the beautiful? It is true, of course, that the fine arts are *par excellence* the imaginative arts, and that they minister chiefly to the esthetic sense. Still, even this fact does not distinguish them wholly from the useful or industrial arts. Intelligence, imagination and pleasure are elements to be found in all the arts. Art really implies intelligence, and it is clear that imagination and pleasure may enter into invention as well as into the so-called creative arts.

What, then, is the basis of the familiar classification? It is the relative historical circumstances under which the respective arts originated and have been developed. The useful, mechanic or industrial arts are allied to productive labor, and their history is the history of labor; while the liberal, polite or fine arts have always been associated with leisure and culture.

Now productive labor, as everybody knows who is in the least familiar with industrial history, was originally imposed by the conquering upon the conquered. It was a function of the slave. Hence to labor has attached the odium of slavery. A life of productive labor was, in the earlier history of mankind, *prima facie* evidence of subjection and inferiority. This was true not only among barbarians, but also among the peoples most highly civilized. In Athens, for instance, all work was assigned to slaves. Among the nobility in Lacedemonia the women were not allowed to spin or weave for fear of degrading their rank. In Rome the trades were called the dirty arts (*sordidæ artes*). Plato and Cicero were alike in regarding the useful occupations as degrading. Even the 'chosen people' imagined that to eat one's bread in the sweat of one's face is one of the severest curses, while people of modern times do not fully realize that under fair conditions it is a blessing, and that under almost any conditions it is better than to eat one's bread in the sweat of another's face. With such ideas of labor it is not surprising that the arts identified with it, or associated with it in thought, should be put in a class by themselves.

On the other hand, leisure being originally, as it is now in some quarters, a badge of respectability, the arts of the leisure class have naturally partaken of this distinction and been regarded as superior to the useful arts. The leisure class could not display its freedom from toil more aptly than by pursuing arts not essential to physical existence. Hence, while all the arts were originally useful, the arts to which members of the leisure class were drawn were those least obviously so. They *selected* those arts which could be pursued only by those who could command their own time. Hence, painting, sculpture, music, poetry and the like were properly called the elegant, that is, the elected, arts, and they soon came to hold the same relation in thought to the useful arts as the leisure class held to the laboring class.

This, then, is the explanation of the long-accepted division of the arts into fine and useful: the monopolization of the fine arts by the leisure class, and the compulsory practise of the useful arts by the slave, the serf and the wage laborer. It is a division based primarily upon a class distinction. The fine arts, speaking generally, involve a greater play of the imagination, a freer expression of individuality, more pleasure than the useful arts, but this is due to the greater leisure and freedom of those who monopolized them as well as to the nature of those arts themselves. If laborers in the industrial arts had more freedom, culture and leisure, and the conditions of their work were made conducive to pleasure, these arts would become fine arts; not so 'fine' as painting and sculpture, perhaps, but fine arts, nevertheless. 'Work without art,' said Ruskin, and by this I suppose he meant work unaccompanied by pleasure, 'is brutality.' But work ought not to be divorced from art. The joy and beauty now associated with the fine arts must become elements of the useful arts as well. "Beauty must come back to the useful arts," said Emerson, "and the distinction between the fine and the useful arts be forgotten. If history were truly told, if life were nobly spent, it would no longer be easy or possible to distinguish the one from the other. In nature all is useful, all is beautiful."[1]

We submit, then, that the commonly accepted classification of the arts is an arbitrary one. Its foundation, the supposedly ignoble character of productive labor, is a false idea. Labor, not leisure, is the real badge of dignity. 'The stone which the builders refused is become the headstone of the corner.' Hence the old classification of the arts, a classification which tends to disparage labor, is an anachronism, and an impertinence. It is, in a way, a gratuitous reflection upon the laboring class.

Before proceeding to reclassify the arts, let us carefully define the scope of art. The word art usually suggests the fine arts. "'Work of art' to most people," says Huxley, "means a picture, a statue, or a piece of bijouterie; by way of compensation 'artist' has included in its wide embrace cooks and ballet girls, no less than painters and sculptors."[2] The word art properly includes 'all the works of man's hands, from a flint implement to a cathedral or a chronometer.' It embraces all phenomena in which intelligence plays the part of conscious and immediate cause. The supplement of art is nature. Art includes everything not embraced by nature.

The field of the arts being thus defined, we may now construct our classification.

All arts are alike in this—their medium is matter. No art can free itself wholly from material things. Some arts, as music and poetry, may seem to do so, for the ideal elements of these arts predominate to such an extent that we forget the material by which they are made manifest—writing and printing materials, musical instruments and sound waves. No matter how idealistic an art may be, it must still deal with matter.

This being the case, a logical classification of the arts may be based upon a classification of material phenomena. And if this latter is an evolutionary classification, that is, if it proceeds from the simple to the complex, the resulting classification of the arts will be in the order of complexity and potential utility. It will also be a classification in which each art will be a means to those above it, that is, a classification of superiority and subordination.

Now one of the most obvious divisions of the material world is into the inorganic, the organic and the superorganic. From the standpoint of evolution these divisions rank in the order named—the organic is higher than the inorganic, and the superorganic higher than the organic. Each division furnishes the material upon which is exercised

[1] 'Essays,' First Series, Essay XII., Art.

[2] 'Evolution and Ethics, and Other Essays,' authorized edition, New York, 1899, p. 10, foot-note.

a special class of arts. There are arts which deal with wood, stone and iron (lifeless elements), arts that deal with living things, and arts that deal with organized groups of men, or societies. Hence there are three grand divisions of the arts corresponding to the three grand divisions of the material world. Simplifying our terminology, we may call them the physical arts, the vital arts and the social arts.

The physical arts are relatively the lowest. The material upon which they are employed is passive. It 'stays put.' The principles underlying these arts are extremely simple. The mechanical principles, for instance, are seven in number. They may indeed be reduced to two—the lever and the inclined plane. Historically probably, as well as analytically, the art of making and using tools comes first. The primitive man who chipped his arrow-head from a piece of flint, and fashioned the shaft of his arrow from a stick of wood, employed art. He was an artist. If in the practise of his art he manifested no sense of beauty, it was due to the pressing demands of the more imperative desires rather than to the absence of the esthetic sense. What birds and beasts, and even insects, possess must have been present in the lowest of men. Archeology shows that even the cave-dweller tried his hand occasionally at the purely decorative arts. But the first arts were the hand arts—manufacture, in the strict sense of that word.

As intelligence increased, and inventive genius was applied, hand-making grew into machine-making. The machine is a combination of tools in the operation of which a natural force, like wind, water, steam or electricity, is usually employed. The machine arts are more complex than the hand arts. Their social potentiality is greater. Their object, like that of the hand arts, is not necessarily the production of articles of vulgar utility only. It may be idealistic in the highest degree. The various fine arts must fall under one division or the other. Hand-making (manufacture) and machine-making (machino-facture) completely cover the realm of the physical arts. Under the first are the manual occupations (handicrafts), and under the second the mechanical occupations, imperfectly designated 'the trades.'

Now, the physical arts that minister to the vulgar wants, or needs, of mankind have reached a high degree of perfection. They are to-day the theater for the display of the highest reaches of inventive genius. A watch, a locomotive, a printing-press, are marvels of ingenuity. We do not wonder that untutored men have worshiped a watch as a superior being. A printing-press, working automatically, will print, fold and deliver twelve thousand twenty-four-page papers in an hour. Machines in almost every industry turn out articles which in quantity, regularity and delicacy of form could not possibly be produced by hand. But the object of these arts has been quantity rather than quality, mercantile utility rather than beauty. Salability has been their main consideration. They have been the instruments of trade and gain, rather than the ministers of joy and life. They have thus been degraded. They are the Cinderella of the household of art. None the less they are noble; and when clothed in beauty, as some day, let us hope, they will be, they will win their full share of admiration and devotion. The repulsion which some profess to feel toward the machine arts is based upon a misconception. It is not these arts which should excite disdain: it is the purpose for which they are employed and the conditions under which they are practised. They could free men from drudgery if properly used; they outrank the genii of fable in serving their master; and they are not in themselves incompatible with pleasure and beauty. But as industrial conditions are to-day, men are not the masters of the machine. They are enslaved by it. Machinery has more slaves than any dominant class ever possessed. Thus it has been, and thus it will be as long as men are 'an appendage to profit-grinding.' Once free men from the machine, give them leisure and culture, and the machine arts will become fine arts. Under normal conditions the element of the beautiful would manifest itself in all work, mechanical or manual, because man is a beauty-loving animal.

It appears, then, that the arts now known as the fine arts must, in our present classification, be distributed among the handicrafts and the mechanical occupations, since they have been selected out because of their idealistic character. They are physical arts, because, like all such arts, they realize the ideal by the exercise of manual or mechanical operations upon brute matter. The artist who paints a picture employs pigment and canvas and brush. To be sure he is supposed to 'mix his paint with brains,' but there is nothing essentially unique in this. Mortar should be so mixed—and dough. The sculptor uses stone and a chisel. The mechanical part of his work is turned over to the machine, from which he himself is free. His art differs in no inherent and absolute respect from that of the industrial artist. Carving a statue to please the eye ought not to differentiate the 'artist' from the laborer who carves a chair to relieve us of 'that tired feeling.' If the one act is accompanied by pleasure, and a manifestation of the beautiful, while the other is not, it is due to factitious circumstances.

It is not to be denied, of course, that the fine arts are the most highly cultivated of all the arts. Their possibilities have, perhaps, been more completely realized than those of the other arts. Certainly this is true with respect to the vital and the social arts. They have drawn to themselves much of the talent freed from the grosser forms of labor. They have touched the highest levels of skill in execution, and of idealistic conception. Zeuxis, it is said, imitated nature so successfully that the birds pecked at his painted grapes, while Parrhasius, his Athenian rival, deceived with his pictured curtain even the practised eye of

Zeuxis himself. Every museum *des beaux artes* evidences lofty flights in the realm of the ideal. Some profess to believe that the climax of art has been reached, that Grecian art will never be surpassed. This is a gratuitous assumption. The soil of art is freedom, leisure and culture; its light and warmth and moisture, appreciation. If men were freed from grinding toil, if the industrial arts had become fine arts, and art appreciation were a common heritage, the growth of even the more imaginative arts would receive an impetus hitherto unfelt, and achieve a development as yet unrealized.

We have now analyzed the physical arts, the arts which deal with non-living matter. They are divided into manufacture, which embraces the handicrafts, and machinofacture, which includes the mechanical occupations. There is no need of a third class to embrace the fine arts, since these are at bottom manual or mechanical, and their fineness is due to the circumstances under which they have been cultivated. Ideally all arts are fine. We now pass to the vital arts.

The world of life is divided into plants and animals. The arts corresponding to these two divisions are the botanical and the zoological. The botanical arts realize the ideal in plant life; the zoological, in animal life. To the former belong agriculture, horticulture, and the like, and to the latter the domestication, breeding and training of animals, and the education of man. It might be more complimentary and gratifying to the human animal if the arts pertaining to his development were given a class by themselves. This may be done, if it is insisted upon. They would be called, of course, the anthropological arts.

Now, the vital arts, dealing as they do with a higher because more complex form of matter, are superior to the physical arts. It will seem strange and illogical at first thought to find farming ranked above music, and gardening above painting. And there is, of course, an element of absurdity in it if we think of the botanical arts as they are usually practised. They are empirical. Their possibilities of use and beauty have only begun to be appreciated. They bear about the same relation to what they might be, as a chant of the Igorrotes does to a Wagnerian opera. There is not a nation on the globe that has given, or is now giving, as much scientific attention to farming as to fighting. Hence the farmer is still a 'hayseed,' and the fighter a tailor's model. But if we think of these arts as they might become—as sustaining a populous world and clothing it with new forms of life and beauty—our estimate will change. If, as we read, Mr. Burbank has developed new species of flowers and fruit, and has produced a spineless cactus which is to be the means of reclaiming the arid regions of the west, he has revealed some of the possibilities of the botanical arts, and done much to remove the stigma that has attached to the cultivation of the soil. Breeders and fanciers are showing what can be done to mold animal life into preconceived forms. They "habitually speak of an animal's organization," says Darwin, "as something plastic, which they can model almost as they please." "It would seem," said Lord Somerville, "as if they had chalked out upon a wall a form perfect in itself, and then had given it existence."[3] Is it less difficult to fashion the ideal in flesh than in clay? The fine arts have been called the 'creative arts.' But the botanical and zoological arts, which are capable of bringing into existence new forms of life, ideal forms, differing in size, shape, color and character from anything that nature has produced, are also creative arts. They continue and supplement the work of the Creator. There seems no absurdity, then, in ranking above the art that paints a flower the art that can produce one; above the art that beguiled the birds, the art that can change the leopard's spots.

At the head of the vital arts is the art which seeks to realize the ideal in the life and character of individual men. Man is an animal, a paragon, if you please, and the 'beauty of the world,' but still an animal. The arts devoted to his physical, mental and moral improvement are, strictly speaking, zoological. They are the highest of the vital arts because they deal with the highest form of life, and outrank all below them in possibilities. The ideal man realized in the flesh, which is the object of these arts, would exceed in beauty and beneficent influence anything that is possible to the painter's brush or the sculptor's chisel. The totality of these arts may be embraced by the word education.

Education employs all lower arts as means. It rests upon them and requires a knowledge of their principles. To educate demands the highest type of mind. It is an art which the world has never properly estimated or appreciated. When ranked as an art at all it has been placed below the fine arts, whereas, when made a fine art itself, it is immeasurably above them. To be sure, there are few who have made it such. The great educational artists may be counted on one's fingers. Each of these men has been as one born out of time. But when the art of education is duly appreciated the world will find a place in its Temple of Fame for such artists as Pestalozzi and Froebel, Herbart and Horace Mann, and the other great teachers who have striven to make the word flesh that it might dwell among men. Education should always be, and should always have been, a fine art.

We now come to the third and last division of the arts, the social arts. The ultimate end of all the arts is a perfected humanity. Hence, in one sense, all the arts are social arts. Here, however, we include only the arts which have for their immediate end the improvement of society, which deal with society as the next lower arts deal with the individ-

[3] See Darwin, 'Origin of Species,' Chap. I.

ual—man, lower animal or plant. The social arts are in reality one art. They are the art of employing all other arts in the realization of an ideal social conception. This art might also be called education, since we speak of the education of the race as well as the education of the individual. It might be called government, if that word were not vitiated by its associations. Professor Lester F. Ward employs the word sociocracy. "This general social art," he says, "the scientific control of the social forces by the collective mind of society for its advantage, in strict homology with the practical arts of the industrial world, is what I have hitherto given the name Sociocracy."[4] Call it what we may, this social art is the highest of all the arts. Its end is a perfected humanity. In realizing this end it utilizes all other arts. It is the art of arts. Its application requires the maximum of intelligence and skill. Its potentialities are as yet undreamed of.

The main divisions and subdivisions of the arts having now been passed briefly in review, it will be helpful to bring them together in tabular form. They will stand as follows:

Art	1. Physical	Manufacture	Handicrafts.
		Machinofacture	Mechanical occupations.
	2. Vital	Botanical	Agriculture.
			Horticulture, etc.
		Zoological	Domestication, breeding and training.
			Education.
	3. Social	Sociocracy.	

[4] 'Outlines of Sociology,' New York, 1898, p. 292.

THE VALUE OF SCIENCE

Chapter IX. The Future of Mathematical Physics

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The Principles and Experiment.—In the midst of so much ruin, what remains standing? The principle of least action is hitherto intact, and Larmor appears to believe that it will long survive the others; in reality, it is still more vague and more general.

In presence of this general collapse of the principles, what attitude will mathematical physics take? And first, before too much excitement, it is proper to ask if all that is really true. All these derogations to the principles are encountered only among infinitesimals; the microscope is necessary to see the Brownian movement; electrons are very light; radium is very rare, and one never has more than some milligrams of it at a time. And, then, it may be asked whether, besides the infinitesimal seen, there was not another infinitesimal unseen counterpoise to the first.

So there is an interlocutory question, and, as it seems, only experiment can solve it. We shall, therefore, only have to hand over the matter to the experimenters, and, while waiting for them to finally decide the debate, not to preoccupy ourselves with these disquieting problems, and to tranquilly continue our work as if the principles were still uncontested. Certes, we have much to do without leaving the domain where they may be applied in all security; we have enough to employ our activity during this period of doubts.

The Rôle of the Analyst.—And as to these doubts, is it indeed true that we can do nothing to disembarrass science of them? It must indeed be said, it is not alone experimental physics that has given birth to them; mathematical physics has well contributed. It is the experimenters who have seen radium throw out energy, but it is the theorists who have put in evidence all the difficulties raised by the propagation of light across a medium in motion; but for these it is probable we should not have become conscious of them. Well, then, if they have done their best to put us into this embarrassment, it is proper also that they help us to get out of it.

They must subject to critical examination all these new views I have just outlined before you, and abandon the principles only after having made a loyal effort to save them. What can they do in this sense? That is what I will try to explain.

It is a question before all of endeavoring to obtain a more satisfactory theory of the electrodynamics of bodies in motion. It is there especially, as I have sufficiently shown above, that difficulties accumulate. It is useless to heap up hypotheses, we can not satisfy all the principles at once; so far, one has succeeded in safeguarding some only on condition of sacrificing the others; but all hope of obtaining better results is not yet lost. Let us take, then, the theory of Lorentz, turn it in all senses, modify it little by little, and perhaps everything will arrange itself.

Thus in place of supposing that bodies in motion undergo a contraction in the sense of the motion, and that this contraction is the same whatever be the nature of these bodies and the forces to which they are otherwise subjected, could we not make a more simple and natural hypothesis? We might imagine, for example, that it is the ether which is modified when it is in relative motion in reference to the material medium which penetrates it, that, when it is thus modified, it no longer transmits perturbations with the same velocity in every direction. It might transmit more rapidly those which are propagated parallel to the motion of the medium, whether in the same sense or in the opposite sense, and less rapidly those which are propagated perpendicularly. The wave surfaces would no longer be spheres, but ellipsoids, and we could dispense with that extraordinary contraction of all bodies.

I cite this only as an example, since the modifications that might be essayed would be evidently susceptible of infinite variation.

Aberration and Astronomy.—It is possible also that astronomy may some day furnish us data on this point; she it was in the main who raised the question in making us acquainted with the phenomenon of the aberration of light. If we make crudely the theory of aberration, we reach a very curious result. The apparent positions of the stars differ from their real positions because of the earth's motion, and as this motion is variable, these apparent positions vary. The real position we can not ascertain, but we can observe the variations of the apparent position. The observations of the aberration show us, therefore, not the earth's motion, but the variations of this motion; they can not, therefore, give us information about the absolute motion of the earth.

At least this is true in first approximation, but the case would be no longer the same if we could appreciate the thousandths of a second. Then it would be seen that the amplitude of the oscillation depends not alone on the variation of the motion, a variation which is well known, since it is the motion of our globe on its elliptic orbit, but on the mean value of this motion, so that the constant of aberration would not be quite the same for all the stars, and the differences would tell us the absolute motion of the earth in space.

This, then, would be, under another form, the ruin of the principle of relativity. We are far, it is true, from appreciating the thousandth of a second, but, after all, say some, the earth's total absolute velocity is perhaps much greater than its relative velocity with respect to the sun. If, for example, it were 300 kilometers per second in place of 30, this would suffice to make the phenomenon observable.

I believe that in reasoning thus one admits a too simple theory of aberration. Michelson has shown us, I have told you, that the physical procedures are powerless to put in evidence absolute motion; I am persuaded that the same will be true of the astronomic procedures, however far precision be carried.

However that may be, the data astronomy will furnish us in this regard will some day be precious to the physicist. Meanwhile, I believe that the theorists, recalling the experience of Michelson, may anticipate a negative result, and that they would accomplish a useful work in constructing a theory of aberration which would explain this in advance.

Electrons and Spectra.—This dynamics of electrons can be approached from many sides, but among the ways leading thither is one which has been somewhat neglected, and yet this is one of those which promise us the most surprises. It is movements of electrons which produce the lines of the emission spectra; this is proved by the Zeeman effect; in an incandescent body what vibrates is sensitive to the magnet, therefore electrified. This is a very important first point, but no one has gone farther. Why are the lines of the spectrum distributed in accordance with a regular law? These laws have been studied by the experimenters in their least details; they are very precise and comparatively simple. A first study of these distributions recalls the harmonics encountered in acoustics; but the difference is great. Not only are the numbers of vibrations not the successive multiples of a single number, but we do not even find anything analogous to the roots of those transcendental equations to which we are led by so many problems of mathematical physics: that of the vibrations of an elastic body of any form, that of the Hertzian oscillations in a generator of any form, the problem of Fourier for the cooling of a solid body.

The laws are simpler, but they are of wholly other nature, and to cite only one of these differences, for the harmonics of high order, the number of vibrations tends toward a finite limit, instead of increasing indefinitely.

That has not yet been accounted for, and I believe that there we have one of the most important secrets of nature. A Japanese physicist, M. Nagaoka, has recently proposed an explanation; according to him, atoms are composed of a large positive electron surrounded by a ring formed of a very great number of very small negative electrons. Such is the planet Saturn with its rings. This is a very interesting attempt, but not yet wholly satisfactory; this attempt should be renewed. We will penetrate, so to speak, into the inmost recess of matter. And from the particular point of view which we to-day occupy, when we know why the vibrations of incandescent bodies differ thus from ordinary elastic vibrations, why the electrons do not behave like the matter which is familiar to us, we shall better comprehend the dynamics of electrons and it will be perhaps more easy for us to reconcile it with the principles.

Conventions Preceding Experiment.—Suppose, now, that all these efforts fail, and, after all, I do not believe they will, what must be done? Will it be necessary to seek to mend the broken principles by giving what we French call a *coup de pouce?* That evidently is always possible, and I retract nothing of what I have said above.

Have you not written, you might say if you wished to seek a quarrel with me—have you not written that the principles, though of experimental origin, are now unassailable by experiment because they have become conventions? And now you have just told us that the most recent conquests of experiment put these principles in danger.

Well, formerly I was right and to-day I am not wrong. Formerly I was right, and what is now happening is a new proof of it. Take, for example, the calorimetric experiment of Curie on radium. Is it possible to reconcile it with the principle of the conservation of energy? This has been attempted in many ways; but there is among them one I should like you to notice; this is not the explanation which tends to-day to prevail, but it is one of those which have been proposed. It has been conjectured that radium was only an intermediary, that it only stored radiations of unknown nature which flashed through space in every direction, traversing all bodies, save radium, without being altered by this passage and without exercising any action upon them. Radium alone took from them a little of their energy and afterward gave it out to us in various forms.

What an advantageous explanation, and how convenient! First, it is unverifiable and thus irrefutable. Then again it will serve to account for any derogation whatever to Mayer's principle; it answers in advance not only the objection of Curie, but all the objections that future experimenters might accumulate. This new and unknown energy would serve for everything.

This is just what I said, and therewith we are shown that our principle is unassailable by experiment.

But then, what have we gained by this stroke? The principle is intact, but thenceforth of what use is it? It enabled us to foresee that in such or such circumstance we could count on such a total quantity of energy; it limited us; but now that this indefinite provision of new energy is placed at our disposal, we are no longer limited by anything; and, as I have written in 'Science and Hypothesis,' if a principle ceases to be fecund, experiment without contradicting it directly will nevertheless have condemned it.

Future Mathematical Physics. This, therefore, is not what would have to be done; it would be necessary to rebuild anew. If we were reduced to this necessity, we could moreover console ourselves. It would not be necessary thence to conclude that science can weave only a Penelope's web, that it can raise only ephemeral structures, which it is soon forced to demolish from top to bottom with its own hands.

As I have said, we have already passed through a like crisis. I have shown you that in the second mathematical physics, that of the principles, we find traces of the first, that of central forces; it will be just the same if we must know a third. Just so with the animal that exuviates, that breaks its too narrow carapace and makes itself a fresh one, under the new envelope one will recognize the essential traits of the organism which have persisted.

We can not foresee in what way we are about to expand; perhaps it is the kinetic theory of gases which is about to undergo development and serve as model to the others. Then the facts which first appeared to us as simple thereafter would be merely resultants of a very great number of elementary facts which only the laws of chance would make cooperate for a common end. Physical law would then assume an entirely new aspect; it would no longer be solely a differential equation, it would take the character of a statistical law.

Perhaps, too, we shall have to construct an entirely new mechanics that we only succeed in catching a glimpse of, where, inertia increasing with the velocity, the velocity of light would become an impassable limit. The ordinary mechanics, more simple, would remain a first approximation, since it would be true for velocities not too great, so that the old dynamics would still be found under the new. We should not have to regret having believed in the principles, and even, since velocities too great for the old formulas would always be only exceptional, the surest way in practise would be still to act as if we continued to believe in them. They are so useful, it would be necessary to keep a place for them. To determine to exclude them altogether would be to deprive oneself of a precious weapon. I hasten to say in conclusion that we are not yet there, and as yet nothing proves that the principles will not come forth from out the fray victorious and intact.[1]

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[1] These considerations on mathematical physics are borrowed from my St. Louis address.

PART THIRD. The Objective Value of Science

Chapter X. Is Science Artificial?

§ 1. *The Philosophy of M. LeRoy*

There are many reasons for being sceptics; should we push this scepticism to the very end or stop on the way? To go to the end is the most tempting solution, the easiest, and that which many have adopted, despairing of saving anything from the shipwreck.

Among the writings inspired by this tendency it is proper to place in the first rank those of M. LeRoy. This thinker is not only a philosopher and a writer of the greatest merit, but he has acquired a deep knowledge of the exact and physical sciences, and even has shown rare powers of mathematical invention. Let us recapitulate in a few words his doctrine, which has given rise to numerous discussions.

Science consists only of conventions, and to this circumstance solely does it owe its apparent certitude; the facts of science and, *a fortiori*, its laws are the artificial work of the scientist; science therefore can teach us nothing of the truth; it can only serve us as rule of action.

Here we recognize the philosophic theory known under the name of nominalism; all is not false in this theory; its legitimate domain must be left it, but out of this it should not be allowed to go.

This is not all; M. LeRoy's doctrine is not only nominalistic; it has besides another characteristic which it doubtless owes to M. Bergson, it is anti-intellectualistic. According to M. LeRoy, the intellect deforms all it touches, and that is still more true of its necessary instrument 'discourse.' There is reality only in our fugitive and changing impressions, and even this reality, when touched, vanishes.

And yet M. LeRoy is not a sceptic; if he regards the intellect as incurably powerless, it is only to give more scope to other sources of knowledge, to the heart for instance, to sentiment, to instinct or to faith.

However great my esteem for M. LeRoy's talent, whatever the ingenuity of this thesis, I can not wholly accept it. Certes, I am in accord on many points with M. LeRoy, and he has even cited, in support of his view, various passages of my writings which I am by no means disposed to reject. I think myself only the more bound to explain why I can not go with him all the way.

M. LeRoy often complains of being accused of scepticism. He could not help being, though this accusation is probably unjust. Are not appearances against him? Nominalist in doctrine, but realist at heart, he seems to escape absolute nominalism only by a desperate act of faith.

The fact is that anti-intellectualistic philosophy in rejecting analysis and 'discourse,' just by that condemns itself to being intransmissible, it is a philosophy essentially internal, or, at the very least, only its negations can be transmitted; what wonder then that for an external observer it takes the shape of scepticism?

Therein lies the weak point of this philosophy; if it strives to remain faithful to itself, its energy is spent in a negation and a cry of enthusiasm. Each author may repeat this negation and this cry, may vary their form, but without adding anything.

And yet, would it not be more logical in remaining silent? See, you have written long articles; for that, it was necessary to use words. And therein have you not been much more 'discursive' and consequently much farther from life and truth than the animal who simply lives without philosophizing? Would not this animal be the true philosopher?

However, because no painter has made a perfect portrait, should we conclude that the best painting is not to paint? When a zoologist dissects an animal, certainly he 'alters it.' Yes, in dissecting it, he condemns himself to never know all of it; but in not dissecting it, he would condemn himself to never know anything of it and consequently to never see anything of it.

Certes, in man are other forces besides his intellect, no one has ever been mad enough to deny that. The first comer makes these blind forces act or lets them act; the philosopher must *speak* of them; to speak of them, he must know of them the little that can be known, he should therefore *see* them act. How? With what eyes, if not with his intellect? Heart, instinct, may guide it, but not render it useless; they may direct the look, but not replace the eye. It may be granted that the heart is the workman, and the intellect only the instrument. Yet is it an instrument not to be done without, if not for action, at least for philosophizing. Therefore a philosopher really anti-intellectualistic is impossible. Perhaps we shall have to declare for the supremacy of action; always it is our intellect which will thus conclude; in allowing precedence to action it will thus retain the superiority of the thinking reed. This also is a supremacy not to be disdained.

Pardon these brief reflections and pardon also their brevity, scarcely skimming the question. The process of intellectualism is not the subject I wish to treat: I wish to speak of science, and about it there is no doubt; by definition, so to speak, it will be intellectualistic or it will not be at all. Precisely the question is, whether it will be.

§ 2. *Science, Rule of Action*

For M. LeRoy, science is only a rule of action. We are powerless to know anything and yet we are launched, we must act, and at all hazards we have established rules. It is the aggregate of these rules that is called science.

It is thus that men, desirous of diversion, have instituted rules of play, like those of tric-trac for instance, which, better than science itself, could rely upon the proof by universal consent. It is thus likewise that, unable to choose, but forced to choose, we toss up a coin, head or tail to win.

The rule of tric-trac is indeed a rule of action like science, but does any one think the comparison just and not see the difference? The rules of the game are arbitrary conventions, and the contrary convention might have been adopted, *which would have been none the less good.* On the contrary, science is a rule of action which is successful, generally at least, and I add, while the contrary rule would not have succeeded.

If I say, to make hydrogen cause an acid to act on zinc, I formulate a rule which succeeds; I could have said, make distilled water act on gold; that also would have been a rule, only it would not have succeeded. If therefore scientific 'recipes' have a value, as rule of action, it is because we know they succeed, generally at least. But to know this is to know something and then why tell us we can know nothing?

Science foresees, and it is because it foresees, that it can be useful and serve as rule of action. I well know that its previsions are often contradicted by the event; that shows that science is imperfect and if I add that it will always remain so, I am certain that this is a prevision which, at least, will never be contradicted. Always the scientist is less often mistaken than a prophet who should predict at random. Besides the progress though slow is continuous, so that scientists, though more and more bold, are less and less misled. This is little, but it is enough.

I well know that M. LeRoy has somewhere said that science was mistaken oftener than one thought, that comets sometimes played tricks on astronomers, that scientists, who apparently are men, did not willingly speak of their failures and that, if they should speak of them, they would have to count more defeats than victories.

That day, M. LeRoy evidently overreached himself. If science did not succeed, it could not serve as rule of action; whence would it get its value? Because it is 'lived,' that is, because we love it and believe in it? The alchemists had recipes for making gold, they loved them and had faith in them, and yet our recipes are the good ones, although our faith be less lively, because they succeed.

There is no escape from this dilemma; either science does not enable us to foresee, and then it is valueless as rule of action; or else it enables us to foresee in a fashion more or less imperfect, and then it is not without value as means of knowledge.

It should not even be said that action is the goal of science; should we condemn studies of the star Sirius, under pretext that we shall probably never exercise any influence on that star? To my eyes, on the contrary, it is the knowledge which is the end, and the action which is the means. If I felicitate myself on the industrial development, it is not alone because it furnishes a facile argument to the advocates of science; it is above all because it gives to the scientist faith in himself and also because it offers an immense field of experience where clash forces too colossal to be interfered with. Without this ballast, who knows whether it would not quit the earth, seduced by the mirage of some scholastic novelty, or whether it would not despair, believing it had fashioned only a dream?

§ 3. *The Crude Fact and the Scientific Fact*

What was most paradoxical in M. LeRoy's thesis was that affirmation that *the scientist creates the fact;* this was at the same time its essential point and it is one of those which have been most discussed.

Perhaps, says he (I well believe that this was a concession), it is not the scientist that creates the fact in the rough; it is at least he who creates the scientific fact.

This distinction between the fact in the rough and the scientific fact does not by itself appear to me illegitimate. But I complain first that the boundary has not been traced either exactly or precisely; and then that the author has seemed to suppose that the crude fact, not being scientific, is outside of science.

Finally, I can not admit that the scientist creates without restraint the scientific fact since it is the crude fact which imposes it upon him.

The examples given by M. LeRoy have greatly astonished me. The first is taken from the notion of atom. The atom chosen as example of fact! I avow that this choice has so disconcerted me that I prefer to say nothing about it. I have evidently misunderstood the author's thought and I could not fruitfully discuss it.

The second case taken as example is that of an eclipse where the crude phenomenon is a play of light and shadow, but where the astronomer can not intervene without introducing two foreign elements, to wit, a clock and Newton's law.

Finally, M. LeRoy cites the rotation of the earth; it has been answered: but this is not a fact, and he has replied: it was one for Galileo, who affirmed it, as for the inquisitor, who denied it. It always remains that this is not a fact in the same sense as those just spoken of and that to give them the same name is to expose one's self to many confusions.

Here then are four degrees:

1°. It grows dark, says the clown.

2°. The eclipse happened at nine o'clock, says the astronomer.

3°. The eclipse happened at the time deducible from the tables constructed according to Newton's law, says he again.

4°. That results from the earth's turning around the sun, says Galileo finally.

Where then is the boundary between the fact in the rough and the scientific fact? To read M. LeRoy one would believe that it is between the first and the second stage, but who does not see that there is a greater distance from the second to the third, and still more from the third to the fourth.

Allow me to cite two examples which perhaps will enlighten us a little.

I observe the deviation of a galvanometer by the aid of a movable mirror which projects a luminous image or spot on a divided scale. The crude fact is this: I see the spot displace itself on the scale, and the scientific fact is this: a current passes in the circuit.

Or again: when I make an experiment I should subject the result to certain corrections, because I know I must have made errors. These errors are of two kinds, some are accidental and these I shall correct by taking the mean; the others are systematic and I shall be able to correct those only by a thorough study of their causes. The first result obtained is then the fact in the rough, while the scientific fact is the final result after the finished corrections.

Reflecting on this latter example, we are led to subdivide our second stage, and in place of saying:

2. The eclipse happened at nine o'clock, we shall say:

2a. The eclipse happened when my clock pointed to nine, and

2b. My clock being ten minutes slow, the eclipse happened at ten minutes past nine.

And this is not all: the first stage also should be subdivided, and not between these two subdivisions will be the least distance; it is necessary to distinguish between the impression of obscurity felt by one witnessing an eclipse, and the affirmation; it grows dark, which this impression extorts from him. In a sense it is the first which is the only true fact in the rough, and the second is already a sort of scientific fact.

Now then our scale has six stages, and even though there is no reason for halting at this figure, there we shall stop.

What strikes me at the start is this. At the first of our six stages, the fact, still completely in the rough, is, so to speak, individual, it is completely distinct from all other possible facts. From the second stage, already it is no longer the same. The enunciation of the fact would suit an infinity of other facts. So soon as language intervenes, I have at my command only a finite number of terms to express the shades, in number infinite, that my impressions might cover. When I say: It grows dark, that well expresses the impressions I feel in being present at an eclipse; but even in obscurity a multitude of shades could be imagined, and if, instead of that actually realized, had happened a slightly different shade, yet I should still have enunciated this *other* fact by saying: It grows dark.

Second remark: even at the second stage, the enunciation of a fact can only be *true or false.* This is not so of any proposition; if this proposition is the enunciation of a convention, it can not be said that this enunciation is *true,* in the proper sense of the word, since it could not be true apart from me and is true only because I wish it to be.

When, for instance, I say the unit for length is the meter, this is a decree that I promulgate, it is not something ascertained which forces itself upon me. It is the same, as I think I have elsewhere shown, when it is a question for example of Euclid's postulate.

When I am asked: Is it growing dark? I always know whether I ought to reply yes or no. Although an infinity of possible facts may be susceptible of this same enunciation: it grows dark, I shall always know whether the fact realized belongs or does not belong among those which answer to this enunciation. Facts are classed in categories, and if I am asked whether the fact that I ascertain belongs or does not belong in such a category, I shall not hesitate.

Doubtless this classification is sufficiently arbitrary to leave a large part to man's freedom or caprice. In a word, this classification is a convention. *This convention being given,* if I am asked: Is such a fact true? I shall always know what to answer, and my reply will be imposed upon me by the witness of my senses.

If, therefore, during an eclipse, it is asked: Is it growing dark? All the world will answer yes. Doubtless those speaking a language where bright was called dark, and dark bright, would answer no. But of what importance is that?

In the same way, in mathematics, *when I have laid down the definitions, and the postulates which are conventions,* a theorem henceforth can only be true or false. But to answer the question: Is this theorem true? It is no longer to the witness of my senses that I shall have recourse, but to reasoning.

A statement of fact is always verifiable, and for the verification we have recourse either to the witness of our senses, or to the memory of this witness. This is properly what characterizes a fact. If you put the question to me: Is such a fact true? I shall begin by asking you, if there is occasion, to state precisely the conventions, by asking you, in other words, what language you have spoken; then once settled on this point, I shall interrogate my senses and shall answer yes or no. But it will be my senses that will have made answer, it will not be *you* when you say to me: I have spoken to you in English or in French.

Is there something to change in all that when we pass to the following stages? When I observe a galvanometer, as I have just said, if I ask an ignorant visitor: Is the current passing? He looks at the wire to try to see something pass; but if I put the same question to my assistant who understands my language, he will know I mean: Does the spot move? and he will look at the scale.

What difference is there then between the statement of a fact in the rough and the statement of a scientific fact? The same difference as between the statement of the same crude fact in French and in German. The scientific statement is the translation of the crude statement into a language which is distinguished above all from the common German or French, because it is spoken by a very much smaller number of people.

Yet let us not go too fast. To measure a current I may use a very great number of types of galvanometers or besides an electrodynamometer. And then when I shall say there is running in this circuit a current of so many amperes, that will mean: if I adapt to this circuit such a galvanometer I shall see the spot come to the division a; but that will mean equally: if I adapt to this circuit such an electrodynamometer, I shall see the spot go to the division b. And that will mean still many other things, because the current can manifest itself not only by mechanical effects, but by effects chemical, thermal, luminous, etc.

Here then is one same statement which suits a very great number of facts absolutely different. Why? It is because I assume a law according to which, whenever such a mechanical effect shall happen, such a chemical effect will happen also. Previous experiments, very numerous, have never shown this law to fail, and then I have understood that I could express by the same statement two facts so invariably bound one to the other.

When I am asked: Is the current passing? I can understand that that means: Will such a mechanical effect happen? But I can understand also: Will such a chemical effect happen? I shall then verify either the existence of the mechanical effect, or that of the chemical effect; that will be indifferent, since in both cases the answer must be the same.

And if the law should one day be found false? If it was perceived that the concordance of the two effects, mechanical and chemical, is not constant? That day it would be necessary to change the scientific language to free it from a grave ambiguity.

And after that? Is it thought that ordinary language by aid of which are expressed the facts of daily life is exempt from ambiguity?

Shall we thence conclude that the facts of daily life are the work of the grammarians?

You ask me: Is there a current? I try whether the mechanical effect exists, I ascertain it and I answer: Yes, there is a current. You understand at once that that means that the mechanical effect exists, and that the chemical effect, that I have not investigated, exists likewise. Imagine now, supposing an impossibility, the law we believe true not to be, and the chemical effect not to exist. Under this hypothesis there will be two distinct facts, the one directly observed and which is true, the other inferred and which is false. It may strictly be said that we have created the second. So that error is the part of man's personal collaboration in the creation of the scientific fact.

But if we can say that the fact in question is false, is this not just because it is not a free and arbitrary creation of our mind, a disguised convention, in which case it would be neither true nor false. And in fact it was verifiable; I had not made the verification, but I could have made it. If I answered amiss, it was because I chose to reply too quickly, without having asked nature, who alone knew the secret.

When, after an experiment, I correct the accidental and systematic errors to bring out the scientific fact, the case is the same; the scientific fact will never be anything but the crude fact translated into another language. When I shall say: It is such an hour, that will be a short way of saying: There is such a relation between the hour indicated by my clock, and the hour it marked at the moment of the passing of such a star and such another star across the meridian. And this convention of language once adopted, when I shall be asked: Is it such an hour? it will not depend upon me to answer yes or no.

Let us pass to the stage before the last: the eclipse happened at the hour given by the tables deduced from Newton's laws. This is still a convention of language which is perfectly clear for those who know celestial mechanics or simply for those who have the tables calculated by the astronomers. I am asked: Did the eclipse happen at the hour predicted? I look in the nautical almanac, I see that the eclipse was announced for nine o'clock and I understand that the question means: Did the eclipse happen at nine o'clock? There still we have nothing to change in our conclusions. *The scientific fact is only the crude fact translated into a convenient language.*

It is true that at the last stage things change. Does the earth rotate? Is this a verifiable fact? Could Galileo and the Grand Inquisitor, to settle the matter, appeal to the witness of their senses? On the contrary, they were in accord about the appearances, and, whatever had been the accumulated experiences, they would have remained in accord with regard to the appearances without ever agreeing on their interpretation. It is just on that account that they were obliged to have recourse to procedures of discussion so unscientific.

This is why I think they did not disagree about a *fact:* we have not the right to give the same name to the rotation of the earth, which was the object of their discussion, and to the facts crude or scientific we have hitherto passed in review.

After what precedes, it seems superfluous to investigate whether the fact in the rough is outside of science, because there can neither be science without scientific fact, nor scientific fact without fact in the rough, since the first is only the translation of the second.

And then, has one the right to say that the scientist creates the scientific fact? First of all, he does not create it from nothing, since he makes it with the fact in the rough. Consequently he does not make it freely and *as he chooses.* However able the worker may be, his freedom is always limited by the properties of the raw material on which he works.

After all, what do you mean when you speak of this free creation of the scientific fact and when you take as example the astronomer who intervenes actively in the phenomenon of the eclipse by bringing his clock? Do you mean: The eclipse happened at nine o'clock; but if the astronomer had wished it to happen at ten, that depended only on him, he had only to advance his clock an hour?

But the astronomer, in perpetrating that bad joke, would evidently have been guilty of an equivocation. When he tells me: The eclipse happened at nine, I understand that nine is the hour deduced from the crude indication of the pendulum by the usual series of corrections. If he has given me solely that crude indication, or if he has made corrections contrary to the habitual rules, he has changed the language agreed upon without forewarning me. If, on the contrary, he took care to forewarn me, I have nothing to complain of, but then it is always the same fact expressed in another language.

In sum, *all the scientist creates in a fact is the language in which he enunciates it.* If he predicts a fact, he will employ this language, and for all those who can speak and understand it, his prediction is free from ambiguity. Moreover, this prediction once made, it evidently does not depend upon him whether it is fulfilled or not.

What then remains of M. LeRoy's thesis? This remains: the scientist intervenes actively in choosing the facts worth observing. An isolated fact has by itself no interest; it becomes interesting if one has reason to think that it may aid in the prediction of other facts; or better, if, having been predicted, its verification is the confirmation of a law. Who shall choose the facts which, corresponding to these conditions, are worthy the freedom of the city in science? This is the free activity of the scientist.

And that is not all. I have said that the scientific fact is the translation of a crude fact into a certain language; I should add that every scientific fact is formed of many crude facts. This is sufficiently shown by the examples cited above. For instance, for the hour of the eclipse my clock marked the hour α at the instant of the eclipse; it marked the hour β at the moment of the last transit of the meridian of a certain star that we take as origin of right ascensions; it marked the hour γ at the moment of the preceding transit of this same star. There are three distinct facts (still it will be noticed that each of them results itself from two simultaneous facts in the rough; but let us pass this over). In place of that I say: The eclipse happened at the hour 24 $(\alpha-\beta)/(\beta-\gamma)$, and the three facts are combined in a single scientific fact. I have concluded that the three readings α, β, γ made on my clock at three different moments lacked interest and that the only thing interesting was the combination $(\alpha-\beta)/(\beta-\gamma)$ of the three. In this conclusion is found the free activity of my mind.

But I have thus used up my power; I can not make this combination $(\alpha-\beta)/(\beta-\gamma)$ have such a value and not such another, since I can not influence either the value of α, or that of β, or that of γ, which are imposed upon me as crude facts.

In sum, facts are facts, and *if it happens that they satisfy a prediction, this is not an effect of our free activity.* There is no precise frontier between the fact in the rough and the scientific fact; it can only be said that such an enunciation of fact is *more crude* or, on the contrary, *more scientific* than such another.

(To be continued)

IS THE MIND IN THE BODY?

By Professor GEORGE STUART FULLERTON
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A NUMBER of years ago the eminent anatomist, Dr. Joseph Leidy, told me that a modern Maecenas had offered to pay for the finest microscopes if he would undertake a search in brains for ideas.

The professor, who never pretended to be either a psychologist or a philosopher, rejected the proposal on the ground that the investigation must be a profitless one. His common sense and common experience of mind and body led him to believe that mental phenomena are not things to be captured as the result of such a method of attack.

But what induced him to take this stand? Common sense and common experience, in some sense of the terms, men have always had—at any rate, they have had what may be called by these names from a very early period. And yet there was a time, and a very long time, during which such an investigation would not have impressed men of acuteness and learning as necessarily an absurd one.

There was a time during which, that is to say, men regarded minds as something frankly and unequivocally material. Something elusive, if you please; something too fine and subtle to be directly apparent to the senses; but, nevertheless, something just as material as wood or stone or flesh or bone, and just as really in this or that portion of space.

Almost at the dawn of reflective thought we find men identifying the mind with the breath which we inhale and exhale; and when, later, the time was ripe for the birth of an atomic theory, a crude and hasty one, it is true, but the forerunner of the one which was to appear later, we find them describing it as composed of atoms, which enter and leave the body as do other kinds of matter.

About four hundred years before Christ, Democritus, who was a man of scientific temper, even if of unavoidably limited scientific attainment, placed before the world his atomistic doctrine. A hundred years later that easy-going philosopher, Epicurus, adopted his theory, and founded a long-lived school. In the first century, B. C., the Roman poet, Lucretius, wrote his magnificent poem 'On Nature,' and set forth in noble verse the Epicurean doctrine touching the universe of things physical and mental.

The nature of the mind and soul, says Lucretius, is bodily; for when it is seen to push the limbs, rouse the body from sleep, and alter the countenance and guide and turn about the whole man, and when we see that none of these effects can take place without touch nor touch without body, must we not admit that the mind and soul are of a bodily nature?

But of what sort of bodies must we conceive this part of a man to be composed? The mind acts with great nimbleness; it is very easily moved, so it is inferred that it consists of bodies very small, smooth and round:

The following fact, too, demonstrates how fine the texture is of which its nature is composed, and how small the room is in which it can be contained, could it only be collected into one mass: soon as the untroubled sleep of death has gotten hold of a man and the nature of the mind and soul has withdrawn, you can perceive then no diminution of the entire body either in appearance or weight; death makes all good save the vital sense and heat. Therefore the whole soul must consist of very small seeds and be inwoven through veins and flesh and sinews; inasmuch as, after it has all withdrawn from the whole body, the exterior contour of the limbs preserves itself entire and not a tittle of the weight is lost.[1]

Lucretius thinks that something analogous takes place 'when the flavor of a wine is gone, or when the delicious aroma of a perfume has been dispersed into the air.' Something is gone, but the weight of objects is not altered by the loss.

For hundreds of years it did not seem to men ridiculous to talk about the mind in this way. Yet they all had the common experiences of mental phenomena that we have. Nor was it the weakness of a single school to be thus grossly materialistic. The Stoic school, the great rival of the Epicurean, and also a long-lived one, was in its way as materialistic. The Stoics identified the soul of man with the warm breath that is found in his body.

Indeed, it is not too much to say that, among that very acute people, the Greeks, from whom we have gained so much, it did not seem at all unnatural to conceive of the mind of man as a breath, or a fire, or collection of fine small material particles. Some raised their voices in protest, but the protest was scarcely effectual.

Now, suppose someone had come to Lucretius and had initiated him into the mysteries of the microscope. Would he have scouted the idea of getting a direct vision of the 'seeds' that constituted the mind of man? I think not; there was certainly nothing in his doctrine to make the idea absurd to him. If, in general, invisible material things can be made visible, and the barrier set by their minuteness can be done away, why should not coughed-out soul atoms be captured and inspected?

But Professor Leidy was amused at the notion of the investigation proposed to him. Why was this? His experience of the mind was no more direct or complete than that of Lucretius. He had never

[1] 'De Rerum Natura,' III., trans. Munro.

given half as much thought to the nature of minds, for he was little interested in psychology. Nevertheless, his common sense—whatever that may be—led him to laugh at a way of looking at things that could not have struck Lucretius and many other able men as absurd at all.

It is extremely interesting to ask why the men of our day, I do not mean the professional psychologists, but the great mass of intelligent persons who do not care much for psychology, and who know little of philosophy, should take up certain ways of regarding things mental, and should unhesitatingly repudiate others which have once been popular. We can not in the least explain it by saying that their own experience of minds leads them to embrace such conclusions. As a rule, they do not reflect upon their experiences of their minds at all, and some of them are hardly capable of serious reflection upon the subject. As early as the seventeenth century, John Locke remarked that "the understanding, like the eye, whilst it makes us see and perceive all other things, takes no notice of itself; and it requires art and pains to set it at a distance, and make it its own object." To this modern psychologists will heartily subscribe.

The fact is that the average man's notions about the mind are a part of his share in the heritage of the race. He who knows something of the history of human thought finds in them the echoes of old philosophies—traces of theories sometimes the most fantastic. The common sense which guides men is the resultant attitude due to many influences, some of them dating very far back indeed.

I have said that, even among the ancient Greeks, there were protests against the materialization of the mind. Both Plato and Aristotle stood out against it, each in his own way. It is true that Plato distributes the soul through the body in a way that might strike an Epicurean as not unnatural—a part of it was below the diaphragm, a part of it in the chest, and a part of it in the head. But he does speak of this last and noblest part in somewhat the same tone as that in which men came later to speak of the human mind. Aristotle follows his teacher in regarding the reason, at least, as something to be carefully distinguished from everything material. However, it is interesting to note that he conceives of the divine reason, or first cause of motion, as *touching* the world *without being touched by it.*

May we not describe this last notion as material at one end, so to speak? If reason is so immaterial that it can not be touched by matter, what does it mean to say that it touches matter? But we must get used to queer ways of talking about minds, if we will follow the history of human thought. The seed dropped by Plato and Aristotle has grown into a tree when we come to Plotinus the Neo-Platonist, who lived in the third century after Christ.

Plotinus was a man of mystical tendencies, but he was both learned and acute. He insists that the soul is an immaterial substance, and he tries to give us a notion of the way in which such a thing can be related to the body. To put it into the body, as Epicurus or Lucretius did, would be to deny its immateriality. This he can not do. To deny that it is related to the body at all is too much even for a philosopher.

In his perplexity he follows a middle course. He tells us that the soul is not in space and is not in things, in the strict sense. But in a certain sense it is in things, or is present to things. It is as a whole in the whole body, and is at the same time wholly in every part of the body; and is, thus, at once divisible and indivisible.

One may legitimately object to this curious doctrine, and criticize Plotinus as giving with one hand what he takes away with the other. It is easy to see what he tried to do, and what he actually did do. He tried to draw a clear distinction between mental phenomena and physical, and to tell us how they are related. He succeeded only in making of the soul an inconsistently material thing, existing in space in an inconceivable way.

But it will not do to treat Plotinus with contempt, and to pass over his doctrine as insignificant. He made an earnest attempt to draw a line between the mental and the physical—surely some such line ought to be drawn—and his influence upon men's minds has been enormous. His doctrine was taken up by Augustine, from whom it passed to the philosophers of the middle ages; and it came ultimately, after undergoing various modifications, to the modern philosophers. Distinct traces of it are to be found in some of the psychologies written at the present day and used in our colleges.

In the seventeenth century that remarkable man Descartes arrived at a fairly clear comprehension of the mechanism of the human body, and of the significance in it of the brain and the nerves. He concluded that the soul or mind has its 'chief seat' in the pineal gland in the brain, and that messages are carried to it from the various parts of the body. Yet he never ventured to put the soul quite frankly and unequivocally in the pineal gland. He still held that the soul was united to all the parts of the body 'conjointly'—the old Plotinic notion.

In other words, he did not go back to Lucretius, and he did not go forward to a clear distinction between mind and body. He remained halting in indecision; he left a dark place for his successors to illuminate with such light as they could furnish. They have been at the work ever since, and have had varying degrees of success.

Now the speculations of the philosophers, especially when they touch upon those things which are supposed to be of great moment to mankind, do not remain the property of the philosophers. They ooze out into general literature and become, so to speak, the common property of mankind. In the present instance, we find in the attitude of the majority of the cultivated persons who surround us to-day unmistakable traces both of the crude materialism which seems so natural to man when he first begins to think about the mind, and of the line of speculation indicated above. Men think of the mind as *somehow in the body,* in the brain; and yet they are not willing to admit that it is *unequivocally* in the body—in it as brain cells are, as blood corpuscles are, as are any of the material constituents of the body itself.

Ask the average undergraduate student—who can not be accused of having done much thinking for himself, but who holds the vague opinions that he has absorbed from those about him—ask him where his mind is, and he will probably answer that it is in his brain. Ask him, further, whether there is any hope of getting at it as one may hope to get at the material constituents of the brain, and I think he will say, No! It is *there,* and yet *not exactly there;* it is there in a Pickwickian sense. He feels as Dr. Leidy did, and his feeling has exactly the same foundation. It rests upon an ancient tradition.

What, then, is the relation of mind and brain? We seem to be left with an 'in' on our hands that is not really an *in* at all, but is something else. What is it? Our student can not tell us, nor can those from whom he has picked up his vague and inconsistent notions.

To those who wish to think clearly all this is naturally unsatisfactory. Those who busy themselves with the problem are impelled to try to make the matter less vague. Now and then, even in our time, men go back, to accomplish this end, to something very like the ancient materialism which the world outgrew so long ago.

Thus we now and then hear it maintained that thought is a *secretion* of the brain. Half a century ago much was said about this, and to many the doctrine seemed plausible. It certainly does appear to make clearer the relation of mind and body, if we hold that mental phenomena are related to the brain as the saliva is related to the salivary gland. If we can say this, we may maintain that the mind is *in* the body in a literal and unambiguous sense of the word.

But may we legitimately speak thus? The secretion of a gland is a something so unequivocally material that it can be treated just like other material things. It can be collected into a test-tube and analyzed by the chemist. Has any one ever succeeded in filling a test-tube with mental phenomena? in bottling and analyzing in a laboratory pains and pleasures, memories and anticipations? Dr. Leidy, who knew a vast amount about the secretions of glands, did not confound ideas with secretions, and would not even attempt to treat them in the same way.

It is, indeed, too late in the world's history to try to revive the crude materialism of the past. Whatever else the philosophers have done, they have fixed our attention upon the striking distinction between mental phenomena and physical. He who has once grasped this may be a semi-materialist—an unconscious materialist—as is the plain man to-day, notwithstanding his assertion that the mind is immaterial; and as is his more learned neighbor the 'interactionist' psychologist, of whom I spoke in a recent paper in this journal.[2] But he can scarcely be a materialist out-and-out.

Hence, men have felt impelled to turn to other ways of making clear the relation of mind and body. Some have said that consciousness is a *function* of the brain; some, that it is the *inside* of that which, regarded from the *outside*, is brain-change; some, that it is the *reality* to which physical phenomena may be referred as *appearance*.

It is not well to let any one of these statements pass without scrutiny. What do we mean when we say that the mind is a function of the brain? Do we mean only that, given certain changes in the brain, certain mental phenomena come into being? It still remains to ask *how* the mental phenomena are related to the brain. Are they *in there?* and if not, where are they? or are they anywhere, in any intelligible sense of the word? The word 'function' is not a word to conjure with. We may call motion a function of brain molecules, if we choose; but evidently a memory or a feeling of pain is not a function of this kind, and the question still confronts us: What kind of a function is it?

As to the statement that mental phenomena may be regarded as the inside of that which, looked at from the outside, is brain-change—this we may take as merely 'a manner of speech,' as a something to say to troublesome persons who ask us difficult questions and must be answered at all hazards. When we say that seeds are inside of an orange, we know what we mean. They are things that occupy space, and can be found in the spaces that they occupy. A leather purse may be lined with silk, and it may contain silver; but try to line a leather purse with painful emotions, and to fill it with hopes and expectations! We play with the words 'inside' and 'outside' when we talk in this way, and it is not proper to play when one is philosophizing, some learned men to the contrary notwithstanding.

Nor should the words 'appearance' and 'reality' be abused recklessly. They have a proper meaning, and we ought to keep to it. We say that a tree seen at a distance *looks* small, but *really is* large; and we say that a stick stuck into water *looks* crooked, but *really is* straight. Certain experiences we look upon as appearances, and certain others, which for some reason we regard as more satisfactory or more normal,

[2] Popular Science Monthly, February, 1907.

we speak of as realities. Both appearance and reality are given in sensation, and we observe a connection between them. They belong to the same order of experiences.

Thus, I may sit in the highest gallery of the opera house, and may say: What *looks like* a row of small shiny discs in the parquet *is really* a row of bald heads. Be it remarked that the reality in this case is a something that can unequivocally be located; it is in the parquet, and it occupies space. It can be seen close at hand, and it can be touched with the fingers. May I say that what *seems to be* a brain-change in one of these heads *really is* a sensation of sound? Is the sensation of sound *there?* does it occupy space? is it literally in the head?

Evidently we are here again concerned only with 'a manner of speech'—with a loose expression which cloaks one's ignorance, and which borrows what force it has from a false analogy. If we say that the sensation of sound is the 'reality' and the brain-change the 'appearance,' we abuse two respectable words, in common use, that have a right to better treatment.

The truth is that it is better to recognize that mental phenomena must not be conceived after the analogy of material things at all. We may, of course, go on talking about mind and body as other people do. In common life a pedantic exactitude of expression is out of place. But when we try to be scientific we must strip off crude inherited materialisms, the echoes of a remote past.

The man who has done this the most completely is the parallelist. The limits of this paper prevent me from setting forth his doctrine, but I have elsewhere[8] tried to show simply and clearly just how much he has a right to mean by it. He denies frankly that the mind is in the body, as also that one has the right to hint, by the use of vague and ambiguous material analogies, that it is *somehow* in the body. It was a philosopher of the seventeenth century who first thought out the doctrine, but it was a scientist of the nineteenth century, Professor W. K. Clifford, who made it popular to us moderns. To him much of the credit for the present revival of the doctrine must be accorded.

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[8] 'An Introduction to Philosophy,' N. Y., 1906, chapter IX.

DRUG ABUSES, THEIR EFFECTS ON THE PEOPLE

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DRUG abuses have become so grave that at last the medical profession is compelled to correct them. The public should learn clearly our mutual positions in the proper and improper use of drugs, which are chemical substances found useful or necessary to combat the effects of disease. They are demanded in many instances where no other known means are available. It is obvious, however, that misuse is capable of vastly greater harm than their absence.

Certain 'schools of medicine' are recognized, differing chiefly in the opinions entertained as to what drugs shall be employed and what effects are to be expected from them, as well as the manner of their administration. The 'schools' most prominent are two; the regular profession of medicine and that of homeopathy. Though starting from the same basis, *i. e.*, long experience in the selection and preparation of remedial substances, begun in the earliest periods of history, a time came when revolt arose from the existing confusion. Hahneman, a vigorous dogmatic thinker, determined to change the point of view hitherto entertained, and in the process accomplished a number of important results. The chief of these was in the preparation of drugs, and in the amounts administered. He evolved a number of opinions and many shrewd conjectures, some fanciful and some based on careful observation, as to drug effects, direct and indirect. To-day, after a century of critical scrutinization of recorded principles, these two schools differ on essential points inconsiderably.

The vital point is that drugs in one form or another are popularly believed to be endowed with enormous powers for good. History encourages this belief, especially when one considers the discovery of cinchona and certain specifics, such as mercury, and later the antitoxins. The utility of drugs, remedial substances foreign to the economy, is of the highest order in many forms of disease. In the future when the principles of their action are fully understood, both from experience and physiology, they will continue to exert even more definite usefulness. Some hygienic and other measures are capable of replacing them, many of supplementing them, but in certain grave emergencies they are absolutely required. To omit their use, and expect to discharge full duty to the sick, is a failure to furnish something essential, permitting a person endangered by the tyranny of disease to suffer neglect. It is conceivable that in the future an adequate growth in knowledge of the inherent resources of the organism may lead to their omission; but that day is not yet come.

Wherever there is demand it is met by supply. An overmastering desire of most people is to secure the largest material benefits for the least money. Where a physician is consulted and medicines are ordered, these must be paid for in addition to the fee for advice, hence all manner of devices are employed to reduce the cost. The fact is too often overlooked that only by the direct application of skilled advice to the instance, then a suitable remedy being chosen, is safety to be secured. The business man might otherwise as well depend on law primers and omit to consult skilled attorneys. The unwarrantable repetition of prescriptions emanating from physicians of admitted wisdom, and the recommending of these to friends and neighbors gratuitously, are obvious abuses of what is essentially an economically scientific procedure.

As commercial enterprises grew in complexity and breadth of scope, these 'favorite prescriptions' began to be manufactured, advertised and distributed in wholesale fashion. People were encouraged to believe that they might thus secure medical combinations of great power at first hand, and the apparent but false economy was broadly welcomed. These preparations were made agreeable, or at least acceptable, and any one could secure a bottle full of promising potentialities guaranteed to overcome whatsoever ills might occur, real or fancied. Hence arose two classes of drug combination, the nostrum, offered directly to the consumer, based on the commercial principle of exploiting 'favorite prescriptions,' and the proprietary preparations offered to the physician, purporting to be improvements, the product of laboratory researches, constituting true chemical discoveries or refinements and specializations in scientific manufacture. As to the former (the nostrum), it is impossible to see, viewed with the utmost charity, any reason for its existence. Of many of the proprietary preparations, it must be admitted that they evidence excellent advances made by the reputable drug manufacturers, who devote much money and scientific effort to the perfection of methods and products. They have, in many instances, however, transgressed their just prerogatives and invaded the territory of the physician. They make diagnoses, teach us pathology and instruct us how to prescribe.

The sales of nostrums have grown so large as to constitute an overwhelming proportion of all medicines consumed. Their unguided use induces drug habits, fetish worship, incalculable harm.

The educated experienced practitioner of medicine has been forced by the reckless drug consumption thus induced to take not only a secondary position, but is placed low in the scale of guiding influence, in legitimate rewards. The sphere of the physician is of largest practical utility to the community. He it is who, by long years of close study, hospital teaching and personal experience, becomes gradually equipped to fill the responsible post of conservator of public and private health, of guide to the delicate human mechanism when disordered. His problem is a complex one for which he must furnish the highest qualities of character, wisdom, tact, sympathy and personal kindliness. He is the one who, even in those situations of gravity when the onslaughts of disease can not be stayed, comes closer to the heart, the soul and person than even the man of God. He should be (and in this as in other ways he seldom fails) in all respects a man, typifying the most estimable advisory qualities of friend, father, brother. No household is safe without a wise family physician in whom the members can repose confidence. He can, and does, furnish far more than medical advice; he is the counselor in a thousand directions, whether in illness, sorrow, domestic catastrophe, mental shock, perils of countless sorts and degrees. He can only display his resourcefulness, his manifold capacities, if he be permitted free access to the household to enable him to foresee, warn and thus prevent those calamities which too often can not be cured. It is an inconsiderable part of his duties to administer drugs, though these are among his keenest weapons. He should possess the fullest knowledge of their uses and employ them with skill and timeliness.

How far could a crew of bankers, of clergymen, of merchants guide and use a man-of-war? What sort of pictures could a man untrained in pictorial art paint, were he provided with the full accoutrements of a skilled artist? How long would a child alone continue to live in a butcher shop stocked full for Christmas feasting? These analogues are mild compared with that of an ailing man or woman turned loose in a chemist's shop to select remedies unaided. Yet many people take advice and swallow drugs, deadly in ultimate intent, incited thereto by each other, by the newspapers, by alluring labels on the bottles, and still regard themselves as shrewd. They often do worse, if, failing good effects from these nostrums (and provided they survive) turning to charlatans, who trade upon human credulity, themselves not realizing that sick bodies always enshrine disordered minds.

The sphere of the physician is not that of a merchant selling wares; he is the scientific and practical guide in times of physical danger. His duties and responsibilities are theoretically, but not practically, understood. The public expects of him who guides the helm in times of disease and threatened death ethical qualities which he seldom fails to furnish. If in his best judgment drugs are needed, he it is who should select and change. He may be less wise than he might, or even than he is estimated, but assuredly he is vastly better fitted at all times to direct and control the course of physical derangements than even the wisest layman.

Commercial principles are comprehensible by all; financial success is obtrusively tangible. A firm earning enormous sums by the sale of remedies is naturally supposed to be offering a valuable product. The professional spirit, the ethical, the scientific principles on which action must be based to be intelligently successful, are thus obscured. The great proportion of people of this country estimate the scientific practitioners of medicine, equipped as they are with years of patient scientific self-sacrificing education, as of small account compared with the material achievements of the great factors of nostrums and proprietary medicines. The sphere of acquired wealth, in comparison with this quiet faithful service, is obvious, speaks a comprehensible language.

The members of our profession in the concrete have quietly submitted to a domination at the hands of these manufacturers which is no less than contemptible. In matters of politics 'money talks.' The great power of the country resides in the public press. With them money also talks. Advertisements are paid for which alone aggregate sums close to the total of the gross earnings of legitimate practitioners. Hence naturally are induced alliances, defensive and offensive, whereby the power of the great drug houses becomes increasingly intrenched for good or evil.

The members of a learned profession are thus made to appear of little account. When they protest, as individuals, their voice is overborne by platoon fires of pseudo-scientific, advertising jargon till most of us become dazed and all but ready to capitulate before we can place our evidence on record, or even get a hearing.

Incredible sums of money are spent by the great drug manufacturing houses to make and hold their power. They are almost impregnable, but not quite. No physician in America earns such an income as is enjoyed by many individual members of these firms who live like royal princes, leaving at death fortunes which, when subdivided, suffice for generations of affluence. Yet the cure of all this peril is simple, but by no means easy of attainment. Physicians should act in concert and consistently. They should acquaint themselves accurately with the facts and educate the public to know where and how drugs may be best used, and especially point out where they should not.

First let us, every one, learn and make clear to the public at all times what are the effects of nostrums. Can they exercise any beneficent purpose? Emphatically no. What good end can they serve? It is difficult to see one. What possible advantage can accrue from this obtrusion of drugs in attractive shapes upon the receptive consciousness of the community? It may be claimed that every man has the right to make free choice of the treatment for his bodily ailments. Yet the practise of self-medication is one of the most deplorable relics of the dark ages when the treatment of bodily ailments was confused with matters of conscience.

Consider for a moment the gravity of a peril for which it is difficult to see a remedy. These aggregations of capital *must sell* to maintain themselves. If the market is oversupplied they *must make another market.* If physicians do not wish to use such preparations as they furnish, they must be induced to do so, *their hands must be forced.* If the manufacturer sells directly to the public, *via* the druggist, every device must be employed to increase retailing to the consumer. If a man has no ailment *he must be taught to think he has one.* If he has recovered from an ailment he must forsooth thereupon be made fat or thin. Women are educated to believe they require a host of remedial articles, in reality quite supererogatory. Babies who would thrive best by instinctive maternal teachings are made to appear in need of special foods, soothing agents, etc. In short, healthy folk are taught to become hypochondriacs. All this merely to furnish a brisk market when selling has grown languid.

One closing thought we commend to all, especially to clergymen and religious folk. Can anything be more venal, more opposed to the fundamental principles of ethics, more an earning of money by encouraging misconceptions of our physical and mental feebleness, than many of the ordinary advertisements in the public press of remedies, of drugs, or other semi-medical materials, waters, instruments, etc.? If these bold emphatic advertising statements contain some elements of truth they are too often grossly overstated. The sale of 'get well quick' remedies for venereal diseases causes a confidence unwarranted. Thus thousands of innocent women are infected, rendered invalids for life.

There is only one safe rule when in trouble. Seek expert, honest, reputable counsel and be guided by it. *This is of paramount importance when the body is disordered because then also is the mind, the judgment, likewise impaired.*

ILLUSIONS OF VISION AND THE CANALS OF MARS

By Professor ANDREW ELLICOTT DOUGLASS
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THAT fascinating mystery, the planet Mars, will again approach the earth this summer. Again the nightly watcher will note the diminishing snow caps at the poles, the dark areas of vegetation, enlarging with the welcome moisture, and, perchance a cloud or two that, lingering over the cold Martian night, is dissipated in the sunrise heat, revealing thus its character.

Again also will hundreds of fine dark lines appear, which from their straightness and artificial appearance, seem to attest the existence of highly intelligent beings upon our neighbor.

It is right and natural that we should first regard these faintest of markings as realities upon the planet. The writer can certify to their apparent genuineness, for he has pictured numbers of them in half a dozen favorable oppositions since 1892. To him they were real until time proved that in the faintest markings astronomers failed of satisfactory agreement. In the larger markings, and even in the larger canals, conflicts of evidence do occur, but are never troublesome. One may confidently say that such realities do exist. But with the very faint canals whose numbers reach occasionally well into the hundreds, discordance reigns supreme, and it is frequently found that different drawings by the same artist antagonize each other across the page.

Considerations along these lines led the writer to study seriously the origin of these inconsistent faint canals by the methods of experimental psychology, and the application of those methods has resulted in a new optical illusion and new adaptations of old and well-known phenomena, all of which apply profoundly to the case in hand. Their description and application follow.

Halo

The most important of these phenomena is the halo.

To observe this, place Fig. 1 at a distance of six to eight feet from the eye and look at it from time to time, taking care to avoid fatigue. Around it will appear a whitish area limited externally by a faint dark line forming a perfect circle, as if traced by a pair of compasses. This external ring or secondary image has a sensible width and appears blackest on its sharp inner edge. When once caught, which is usually at the first view, it is a striking phenomenon. I find on the whole that trained eyes are the ones which see it most quickly.

A more beautiful and elegant way of making the experiment is by standing a black-headed hat pin in the middle of a white-walled room, and looking at it against the distant white background. Around the head of the pin will then appear this halo, more beautiful than before, suspended in mid-air, in the good old-fashioned manner of saintly halos.

The experiment described above gives the 'negative' halo. It will be generally referred to in this article, because it is more easily seen than the 'positive.' The 'positive' form of the halo, however, is most readily seen by a similar method. Let a white-headed pin be substituted for the other, and looked at against a black background. Similarly, a white circle is seen. The difficulties in this case arise from the reflections on the head of the pin and its generally less even illumination.

FIG. 1. THIS SPOT SHOULD BE VIEWED FROM A DISTANCE OF SIX OR EIGHT FEET, with care to avoid fatigue or after-images, in order to see the fine dark halo ring about it at the distance indicated by the smaller dot.

The effect, however, is the same. Extending all round the head of the pin at a distance of about 7′ of arc (one inch at a distance of 500 inches) is an intensified zone in which the color of the background appears stronger; and outside of that a reduction zone, or ring, or secondary image, in which the intensity of the background is reduced by the addition of some of the color of the spot observed.

In order to find the cause of this halo, many tests were made, of which the first was upon the size of the central spot. It was found that the distance from the edge of the spot to the secondary image is constant; that the width of the secondary image increases to some extent with the size of the spot, and that the intensified area increases its intensification with the size of the spot. If the spot is so small as to be barely visible, the halo may still be seen, but the intensified zone then appears of the same intensity as the background.

If the spot is enlarged sufficiently, both positive and negative halos are seen along its margin, one outside and one inside, so that in a straight line separating light and dark areas, the positive halo may be seen in the dark area, and the negative halo in the light. If two small spots are placed so that their halos intersect, the halo of each may usually be seen complete. If the spots are larger, the halos can not be traced within each other's precincts, and on enlarging the spots still more, they soon act as one mark with regard to the halo, which assumes an elliptical form around them. From these and other experiments along the same line, it appears that the intensified zone or white area, as I shall generally call it, referring to the negative experiment, displays an increased sensitiveness to presence or absence of color of the spot looked at, but a decided deadening in the perception of details.

My first idea in regard to this halo was that it came to life like the camera ghost, from reflections between lens surfaces in the eye, but I found that it could be produced through any portion of the crystalline lens. A pin hole 1/50 inch in diameter passed before the pupil of the eye demonstrated this.

It then seemed possible that some form of halation in the membranes close to the retina might produce this effect. The common photographic halation ring, which closely resembles it, is produced by reflection from the back of a glass plate but can only occur under certain conditions. This halo, however, occurs on all margins and can not be due to that cause.

FIG. 2. PHOTOGRAPHIC HALATION RING ABOUT CANDLE FLAME, formed by reflection inside the glass plate on which the picture was taken, very similar in its appearance to the halo here described.

At this stage, a certain 'chromatic ring,' described below under that heading, was observed, and suggested some obscure color conditions as the cause. Hence, color tests were made in large numbers, and the black spot was tried on different colored backgrounds without effect. Different colored spots against a dark background were also observed without effect, save that the secondary image when sufficiently bright was seen to be of the color of the spot itself; therefore color was not responsible for the halo.

But these color observations opened up a very interesting line of study. The color tests had to be made in the positive form with all the attendant difficulties of fatigue and after-images. It was found that a short gaze at a red disk on a black background, followed by a slight movement of the eye to one side, carried away a dark green after-image of the disk surrounded by a red margin, about the size of the intensified zone. This intensified zone became still more conspicuous by longer fixation of the gaze upon the colored spot. To observe this, half-inch disks of red, yellow, green and blue paper were pasted vertically on ends of long needles and placed in strong lamp-light at a distance of eight feet from the eye. After long unwinking gaze at one of these disks, until general color sensitiveness seemed to be disappearing and the color of the disk itself seemed to be spreading out around it, a quick closing of the eye, or the mere placing of a sheet of paper close before the open eyes, revealed a very interesting succession of changes, as follows:

1. A black or dark green disk with a limited red margin filling the intensified zone, limited by the dark halo. This effect lasted for a very brief instant of time, like the common positive after-image.

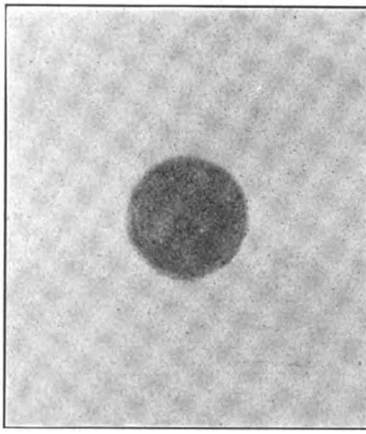


FIG. 3. 'DOT' MOTE OUTSIDE THE YELLOW SPOT.

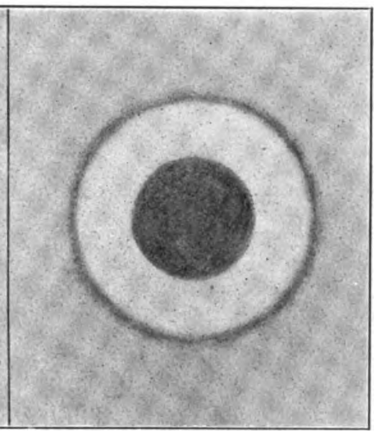


FIG. 4. 'DOT' MOTE IN YELLOW SPOT BUT NOT IN FOVEA.

2. The outline soon reappeared; the red disk and all white objects taking a dark indigo-blue color, the remainder of the field being a bright yellow. This effect might last a minute or two.

3. During the height of this effect a negative halo appeared for a time around the dark after-image of the disk at the usual distance of 7′. The success of this experiment depends largely upon steadiness of vision and avoidance of winking. The determination of the effect of different colors and conditions offers a fine field for investigation.

The next test with a view to locating the cause of this halo phenomenon was made on motes that so often float by the line of vision. This was done by looking at a highly-illuminated area through a small pin hole held close to the eye. Three classes of motes were observed: First, the usual cell fragments and groups; second, rapidly moving objects probably of similar character, and, thirdly, minute black dots which from their motions seemed to be located in the same region as the first, probably not far in front of the retina. On this last class, some beautiful halo phenomena were observed.

When one of these spots was outside a region identified as approximately the yellow spot, it appeared as a circular dark area of some 30′ diameter as shown in Fig. 3. When it came within the yellow spot, it became lighter, and was surrounded by the halo, with its intensified zone and secondary image well defined as in Fig. 4. When, however, it came within the region of most distinct vision, which was very rare, it gave the most beautiful halo effect I have yet seen. It had a dense, black spot in its very center, usually well rayed; then, a light zone limited by an intense black ring, which in turn produced its own complete halo. This form is shown in Fig. 5.

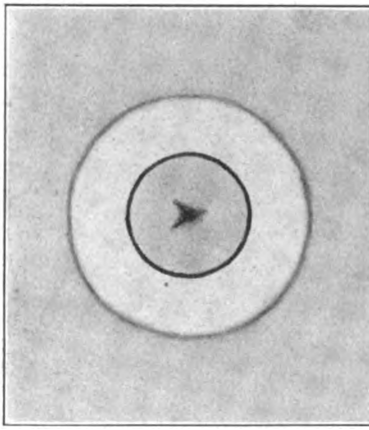


FIG. 5. 'DOT' MOTE IN FOVEA.

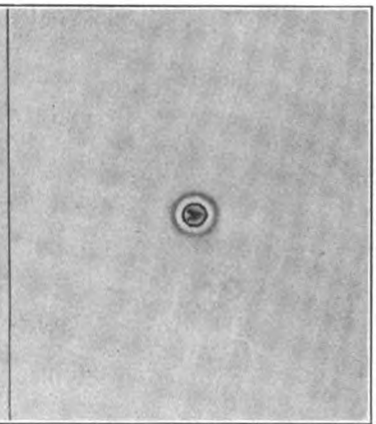


FIG. 6. SAME AS FIGURES 5, VIEWED AT CLOSE RANGE. Notice different length of rays compared to diameter of ring.

This mote observation is by no means easy. I have often waited fifteen minutes for a mote of this type to appear, and only once have I kept one in sight for any length of time. It then remained in the center of vision for at least twenty minutes. Usually, they float past the center of the vision and give one only a brief view. The size of pin hole used is 1/50 inch. With a much larger hole, say 1/20 inch, they become blurred. By getting near a large lamp shade so that a wide angle of light is viewed, they are best discovered. Then one may retreat from the light and view them as illustrated in Figs. 3, 4 and 5.

The rays observed in the central spot are very interesting. Their length offers a means of measuring the height of the spot above the retina. A short calculation upon approximate data results in 0.002 inch as the distance of the spot from the retina.

It is true that these mote observations require great patience, but the beauty of the phenomena repays the effort. There is a sharpness and a density about the inner halo around the spot itself which does not characterize the ordinary outer halo. For such differences I have no explanation to offer.

Not only is the cause of these details very difficult of detection, but the origin of the whole halo phenomenon is equally so. It probably lies in the obscure reactions that change light waves into nerve impulses. One thing which the intensified zone does do is to help correct for rays which the irregular refraction of the eye scatters across a margin; and so this light area fulfils some psychological necessity.

The fact that in the first flash of after-images this zone becomes occupied by the color of the object looked at (like the common positive after-image) suggests that it is a zone in a condition of expectant attention with reference to that color. If, for example, a red disk is observed, the nerves that perceive that color are in full activity, where the stimulus of the image falls on the retina. For a certain distance away from the active retina, they are aroused into a condition of readiness for activity or expectant attention. The secondary image acts like the fatigue area, for it reverses in the after-image.

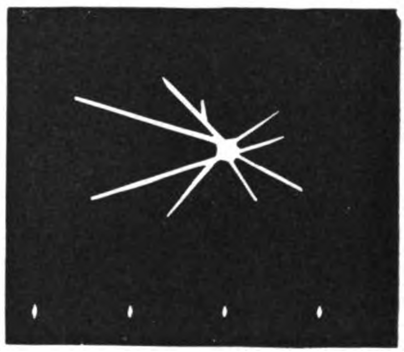


FIG. 7. STELLAR RAYS.

The significance and application of the phenomena are easier. From the psychological standpoint, its immediate application is to questions of contrast. Contrasts are divided into two classes: First, successive contrast, due to fatigue and rest; second, simultaneous or marginal contrast, now seen to be a subordinate part of this halo phenomena. Marginal contrast has been long known, and its after-image, the 'Lichthof' of Hering, has been described. The fact that the halo phenomenon definitely limits the region of marginal contrast and displays a secondary image in a definite position proves it to be the more fundamental phenomenon. We have here, therefore, a new illusion of interest to psychologists and of great significance in its application to astronomical work.

RAYS

Unlike the halo, the ray phenomena are familiar and involve no new principle, but the idea of rays around a black spot is new to me, and quite as important as the halo in its application to visual work by telescope or microscope. As all know, the rays on a star are produced by irregular refraction in the eye, originating in what are known as the stellate figures. The figures seem to be construction lines, as it were, in the crystalline lens, and develop during its growth. They are permanent in form, when adult years are reached, and may be

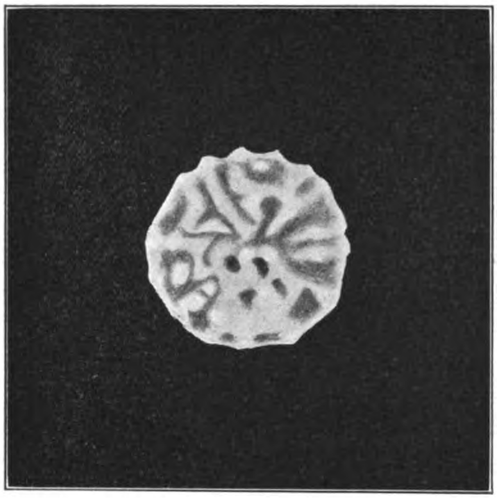


FIG. 8. STRUCTURE LINES IN CRYSTALLINE LENS.

seen with ease by the methods commonly explained in books upon experimental psychology.

If white rays may be seen around a white star on a dark background, then black rays must be visible around a black spot on a white background. They may be easily seen by screening the greater part of the pupil and allowing light from a black spot to pass through its margin. This is best done by a small circular screen on the point of a needle. By slight perseverance all the principal rays seen on a star may be perceived on the black spot. These are always present in the eye, but are not commonly perceived, because they are drowned out in the lighter background, and habit compels us to disregard them. Their importance in astronomical work is at once evident when I state that with the head in a definite position, I found it easier to see certain lines on the planet Mars and those easier lines coincided in direction with the two black rays represented in Fig. 9. It is evident that observations made with the greatest possible care ought to show these canals like marks, and if two of these rays be parallel, as may easily happen in an astigmatic eye, some of the canals should appear double.

FIG. 9. RAYS ON A BLACK SPOT OBTAINED BY SCREENING ALL THE PUPIL EXCEPT THE MARGIN OF THE (LEFT) SIDE. These rays are the two long rays on the left in Fig. 7.

Irradiation.—Next to the black rays in importance is the matter of irradiation as analyzed by means of ray forms. The method of investigation is as follows: Make a small hole in a window blind and observe the sky through it by different distances. From near-by the outline of the hole is well perceived, but, as one draws away, the rays soon obscure the hole itself, so that its form and size can not be perceived. At these different distances, the width of the rays varies with the true angular size of the hole. For example, I found at ten feet an irradiation of 2′ and at three feet an irradiation of 6′, because at the nearer point the rays are three times as wide and overlap each other at three times the distance from the hole. Irradiation then is the merging together of the rays, and on any straight line of separation, is proportional to the total ray light on the corresponding hemisphere about a star.

Color, size, intensity and perfection of eye are positive factors in irradiation. The negative factor is the background, and the result depends upon the sensitiveness of the eye at the time of observation. Some general results we can see at once. Irradiation is not necessarily the same in any two eyes or in any two directions. It varies with fatigue of the retina and probably with use of the eye in some unusual position, producing unusual conditions of pressure upon the eye-ball. Ordinarily, its amount depends directly on contrast between the areas observed and on the size of the central nucleus of rays in the desired direction. This nucleus must not be assumed to be centrally located on its source.

Best Part of Lens.—A very important bit of information derived in this study of the rays is the location and size of the best part of the crystalline lens. This is done by trying smaller and smaller diaphragms over the eye until the rays cease to appear. They will be found to persist in rudimentary form even when the diaphragm is as small as 1/16 of an inch. This is of great significance in telescopic and microscopic work, because it shows how small the emergent pencil of light must be to avoid the excessive formation of rays. Even at best, they can not be hindered entirely. The use of lower powers with large emergent pencil is therefore very dangerous. The optically superior part of the lens occupies a small irregular area near the center with irregular extensions out toward the margin. Even the best part is far from perfect.

Detached Spots.—An interesting variation of stellar rays has been observed at least in one case. A gentleman drew for me the rays as they appeared to his eye in the experiment described above (see Fig. 7), and while working asked me if I had placed a number of smaller pin holes around the large one. Fig. 10 represents this. It is perfectly possible for detached spots of this kind to be produced by some irregularity of the lens structure and thus to supply illusive satellites to planets or fictitious companions to double stars.

Chromatic Rings

The illusive chromatic rings which follow do not bear so much on questions of Martian topography as the preceding halo and rays. Yet they are interesting of themselves and have an influence on color estimations. The first is the broad prismatic ring which extends from about 3½° to 5° from the source of light with red on the outside and green or blue on the inside. This shows well on any brilliant light such as the full moon or a bright electric light.

Fig. 10. Rays and Detached Spots.

The second is a narrow blue ring, of interest on account of its beauty. It is best seen on an electric arc light of intense blue color—and the less continuous spectrum the light shows, the better. Standing at a distance of one hundred and fifty or two hundred feet, one may see a beautiful narrow blue line forming a circle fully two feet in diameter about the light. As the color of the light changes to yellow, which it frequently does, the ring rapidly disappears into the center of the light.

This ring may be seen in the laboratory by passing the blue light of the spectrum through a pin hole. In mid-blue its radius is about 12′. Various experiments show that this illusion is produced at the margin of the pupil by the bending of the blue rays too sharply toward the optical axis of the eye. These rays therefore focus in front of the retina and on reaching it form a blue ring outside of the true image.

Radiating Lines from Near the Center of a Blank Disk

The only remaining illusion to which I call attention is one of much importance in planetary work, but one for which I shall not attempt an explanation. Frequently in observing a blank white disk, lines have appeared to me to radiate from some point near the center. When first I observed lines of that character, not knowing whether they were really there or not, I considered them genuine and for a long time represented them in the form of a star with four or eight rays. At last when they did not show agreement among themselves I concluded they must be illusions. This was verified by specific trial, proving that such lines appear on perfectly blank areas. The rays so observed are sometimes double.

Application of these Phenomena

Against the obstacles of bad atmosphere, minuteness of detail and faintness, the observer has to wage a hard fight, and it is a matter of congratulation that he sees such faint canal-like marks on the very limit of vision. With full records the public may then discuss the interpretation.

The ray illusion is to me a very satisfactory explanation of many faint canals radiating from those small spots on Mars, called 'lakes' or 'oases.' The only objective reality in such cases is the spot from which they start. The reader will notice that rays on opposite sides of a star are usually in line. So when two lakes or oases lie along such a line they will appear connected by a canal. Nor do the oases need to be very close together. A ray 16′ long to the naked eye appears 4″ long on a planet magnified 240 diameters. With the planet Mars 16″ in diameter the ray then extends one fourth across it. It appears like a canal over one thousand miles long.

I believe the industrious observer has found and will find it difficult to avoid instinctively placing his head in a position favorable to producing combinations of this kind. After he has laboriously memorized the leading details, so that he may recognize what he sees, when, for an instant, Heaven vouchsafes him a brief view, he naturally has a powerful inclination always to observe in the same posture, for he finds that with a slight movement of his head his structure of fainter canals is liable to disorganization. This insistence upon the same attitude is at once understood when we consider a larger part of the faint canals to be due to rays in the eye.

We have here the medicine to prevent this disease in the future. Let the observer constantly vary the position of the head. As soon as the seeing becomes sufficiently good to reveal fine detail, let the movement of the head begin. A rotation through an arc of twenty or thirty degrees ought to be large enough to test thoroughly any fancied combination of canals. Drawings carefully made in this way will have one source of error eliminated.

The halo with its light area and secondary image accounts for details which have no objective reality, such as bright limbs of definite width, canals paralleling the limb or dark areas, numerous light margins along dark areas and light areas in the midst of dark—abundantly exemplified in Schiaparelli's map of 1881–2.

When a ribbon-like mark has sufficient width, it must appear double; for the positive secondary image of the adjacent light areas will appear within it. To this end its apparent width to the naked eye must be some 8′ or 10′ (if eyes are alike in this dimension). In a telescope magnifying, say, 400 diameters, this width need be only a little over 1″. If the planet is 16″ in diameter (a rough average of its favorable position in recent years) this will amount to closely 10° on its surface. Now the double canals of Schiaparelli, in 1881–2, and of Perrotin and Thallon, in 1886, are frankly of this width and, I believe, are due to this cause. In any case the test to be applied is evidently the relation between the apparent width of a double and the radius of the halo illusion. The prevention of error in the future will evidently be the application of different powers to each canal, particularly a low power which will make its width appear less than 6′. This must be done with care for low powers increase the number of rays.

The halo illusion is also responsible for marginal canals. When a dark area becomes 6′ or 8′ wide, it appears double, having a light interior and dark edges. With any increase of width the dark edges, giving the effect of the marginal canals, remain. Hence along the edge of any dark area there appears a fictitious canal. Professor E. W. Maunder observed this in his excellent artificial planet study of a few years ago. I believe that high powers by reducing contrast will help to eliminate this error.

The mention of the chromatic rings draws attention to chromatic aberration in the eye and in the telescope. This effect in the telescope is so great that colors in a refracting telescope are not in the least trustworthy. The blue-green tint attributed to the dark areas on Mars is a product of the telescope. Its existence on our neighbor can only be verified by the use of a reflector.

Thus in conclusion we see that there are fundamental defects in the human eye producing faint canal illusions, that these have worked serious injury to our observations in the past and that in the future they may be avoided chiefly by the simple expedients of varying the position of the head and using a wide range of magnifying power.

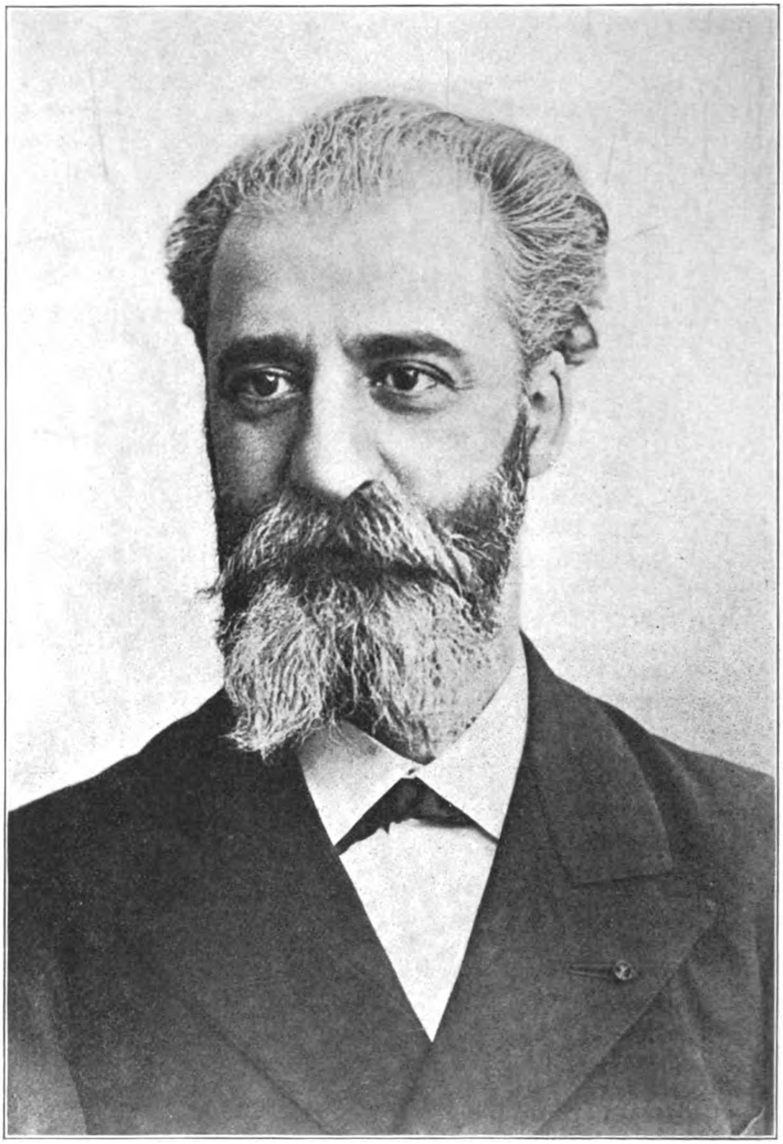
THE PROGRESS OF SCIENCE

BERTHELOT AND MOISSAN

In the deaths of Berthelot and Moissan, France has lost its most illustrious chemists and the world two of its leading men of science. At the celebration held at the Sorbonne in 1901 in honor of the jubilee of the scientific work of Berthelot, Moissan said in his address: "As soon as you touch a question you extend it by generalizing it." The two great chemists indeed typify the changing conditions of scientific performance and of the scientific career. The more than a thousand publications of Berthelot cover a great part of the field of chemistry ranging from minute researches to the widest generalizations. He was a historian, an archeologist, a man of letters, an educational administrator and a statesman as well as a chemist. Moissan, on the other hand, obtained eminence by methods which it appears must become more common with the increasing specialization of science—intensive work in a comparatively narrow field.

Marcelin Pierre Eugène Berthelot was born eighty years ago, the son of a physician. His first scientific work, published in 1850, was on a method of liquefying gases. His thesis for the doctorate was on glycerine and the fats, opening up important questions in organic chemistry, which he followed by his work in synthesizing fundamental organic compounds, such as alcohol, acetylene and benzene. Berthelot then spent fifteen years attempting to lay the foundation of chemical mechanics by a study of the heat changes involved in chemical reactions. While all his principles have not been accepted, this work is one of the most important in the history of chemistry, both as regards detailed discoveries and broad generalizations. One of its incidental results was his study of explosives and the theory of explosion. Berthelot next turned his

Plaque Struck in Honor of Berthelot on the Occasion of the Jubilee of His Scientific Work.



HENRI MOISSAN

attention to problems of vegetable chemistry, discovering the methods by which free nitrogen can be fixed under the influence of electrical discharge and the part played by the microbes of the soil in the fixation of nitrogen. For these researches a laboratory was built for him at Meudon. At the same time Berthelot published a series of important works on the history of chemistry and of alchemy, showing wide scholarship and archeological research. He also published a series of works on the philosophy of science, of ethics and of education.

Berthelot was active in public affairs. During the siege of Paris he was president of the committee on defense, in 1876 he was appointed inspector general of higher education and in 1881 he was made a life senator. He was for a time minister of public instruction and later minister of foreign affairs. He was for many years permanent secretary of the Paris Academy of Sciences and was a member of the French Academy.

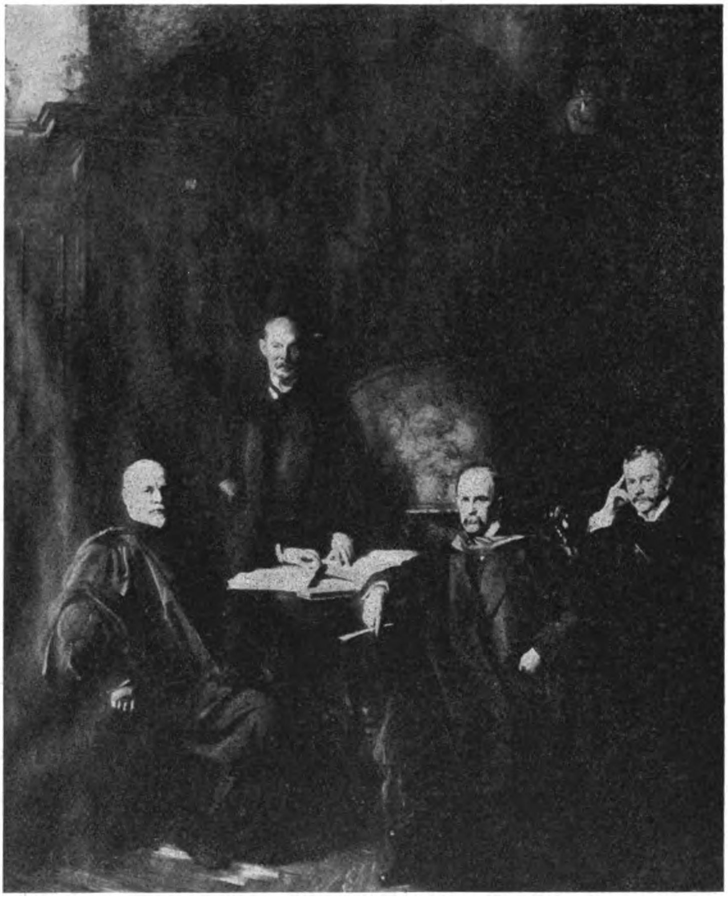
Returning from a meeting of the academy, Berthelot survived the shock of his wife's death by only a few minutes. The public funeral voted by the parliament before its adjournment as a mark of respect, the ceremonies of the national funeral at the Panthéon and the closing of all schools in France demonstrate in how high honor the French people hold their eminent men of science.

Henri Moissan was born in 1852, and his first work, published in 1874, was concerned with the absorption of oxygen and the emission of carbonic acid by plants kept in a darkened room. In 1880 he received the doctorate of science for work on the oxides of the metals of the iron group. He became eminent for his work on the isolation of fluorine, which he communicated to the Paris Academy in 1886, and which was followed by important researches on the chemical and physical properties of fluorine and its compounds. Subsequently Moissan took up the subject of high temperature researches, and became popularly known for the artificial production of diamonds. In his work with the electric furnace, Moissan investigated in detail a number of individual chemical reactions, including the formation of calcium carbide, which have been of great importance for the progress of inorganic chemistry. Moissan was elected a member of the Academy of Sciences in 1891, and, after teaching in the École supérieure de Pharmacie, became professor of inorganic chemistry at the Sorbonne in 1900.

THE FOUNDERS OF THE MEDICAL DEPARTMENT OF THE JOHNS HOPKINS UNIVERSITY

THE portrait group of Drs. Halstead, Kelly, Osler and Welch of the medical department of the Johns Hopkins University, painted by Mr. John S. Sargent, and here reproduced, has now been brought to the country and formally presented to the university by Miss Garrett. The painting is highly esteemed as a work of art, the critic of the London *Times* holding that it will do more to perpetuate the names of the subjects than their scientific achievements. However this may be, the work of these men and their associates, whether recognized or not, is and will remain an important part of the foundation of higher education in the United States.

When the Johns Hopkins University was opened in 1876, it set new standards of university work. For the first time in this country graduate work, research and publication were given their proper place. The men who taught and advanced knowledge and the men who advanced knowledge as they learned were the university rather than the buildings and equipment. The establishment of the medical department in 1893 did for medical education and for professional education what the university had done earlier for graduate work. Here for the first time to the fullest degree were united broad culture, expert training and research work. In some ways the achievement of the medical department has been even more notable than the earlier performance of the graduate department. In 1876 the time was ripe for a university, and a considerable endowment was available at Baltimore free from conditions. In 1893 a broadening of the medical curriculum was evidently needed, but the Johns Hopkins had less means than the other institutions. It accomplished what it did by bringing together a group of men notable for



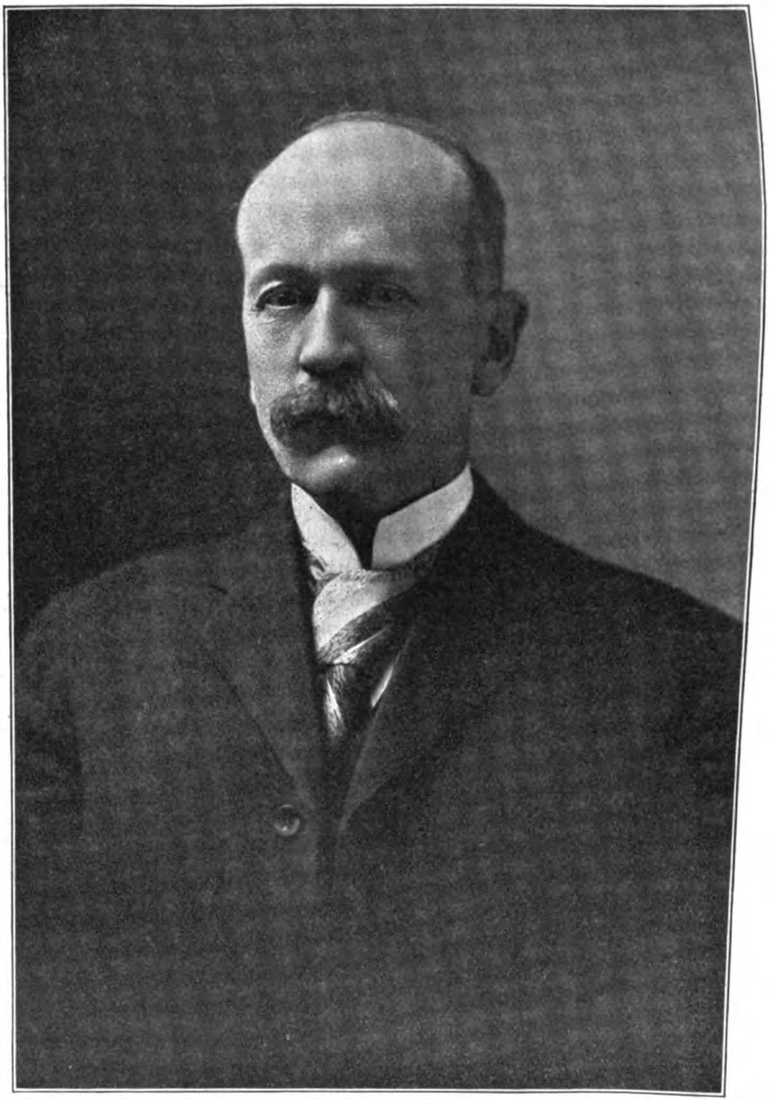
PORTRAIT GROUP OF DRS. HALSTEAD, KELLY, OSLER AND WELCH, OF THE MEDICAL DEPARTMENT OF THE JOHNS HOPKINS UNIVERSITY.

broad culture, professional skill and scientific research, and their spirit and example has made the medical department of the Johns Hopkins University a model of what a medical school should be.

THE DIRECTORSHIP OF THE U. S. GEOLOGICAL SURVEY

DR. GEORGE OTIS SMITH has been appointed director of the U. S. Geological Survey to fill the vacancy caused by the election of Dr. Charles D. Walcott to the secretaryship of the Smithsonian Institution. Dr. Smith received the bachelor of arts degree from Colby College in 1893, and the doctorate of philosophy from the Johns Hopkins University in 1896, in which year he was appointed assistant geologist to the Geological Survey, being made geologist in 1901. He has had charge of the geological work in New England and of work in petrology.

The work of the survey has developed with remarkable rapidity under the direction of Dr. Walcott, the appropriation for the current year being in the neighborhood of a million and a half dollars, and the directorship of the survey having become one of the most important and influential



DR. CHARLES D. WALCOTT

SECRETARY OF THE SMITHSONIAN INSTITUTION

scientific offices in the country. On March 13, the retiring director was entertained at a banquet by his colleagues, which was attended by some two hundred and fifty members of the survey, and their guests. Colonel H. C. Rizer, chief clerk, presided, and addresses were made by representatives of the different departments of work: Mr. Bailey Willis spoke for the geologic branch, Mr. W. M. Beaman for the topographic branch, Mr. M. O. Leighton for the water resources branch, Mr. S. J. Kübel for the division of engraving, and Mr. F. H. Newell for the reclamation service. Dr. Charles B. Dudley spoke of the fuel-testing work of the Geological

Survey. A letter from Mr. Arnold Hague was read, as also a telegram from Mr. Henry Gannett. Mr. Gifford Pinchot paid a tribute to Mr. Walcott in relation to the forestry work of the government. The closing address was by the Hon. James R. Garfield, secretary of the interior.

SCIENTIFIC ITEMS

We regret to record the deaths of Professor W. H. Bakhus-Rooseboom, professor of physical chemistry at Amsterdam; of M. Marcel Bertrand, professor of geology in the Paris School of Mines, and of Professor Ernst von Bergmann, the distinguished German surgeon.

Lord Lister celebrated his eightieth birthday on April 4, on which occasion it was announced that a collected edition of his scientific papers would be published.—The London Society of Dyes and Colors has founded in honor of Sir William Perkin a Perkin medal to be conferred for scientific and industrial work connected with the dyeing industries.—Professor George T. Ladd, who recently retired from the active duties of the chair of philosophy at Yale University, has gone from Japan to Korea, at the invitation of Marquis Ito, in the interest of the educational development of the country.—The Prussian ministry of education has appointed Professor Felix Adler as Theodore Roosevelt professor in the University of Berlin for the year 1908–09, upon the nomination of the trustees of Columbia University, where he holds the chair of political and social ethics.

The new buildings of the Carnegie Institute at Pittsburg were dedicated with imposing ceremonies on April 11, in the presence of a large number of invited guests from Europe and the United States. The ceremonies were extended through three days. Previous to the dedication it was announced that Mr. Carnegie had given $6,000,000—four million to be added to its endowment and two million for the Technical Schools, half for further buildings and half for endowment.

At the meeting of the Association of American Agricultural Colleges and Experiment Stations at Baton Rouge last November a resolution was adopted instructing the incoming president of the association to appoint a commission of five persons to inquire into and report to the association on the organization and policy that should prevail in the expenditure of public money provided for experimentation and research in agriculture. The president of the association, Dean L. H. Bailey, of Cornell University, has appointed the following commission, the first two representing persons outside agricultural investigations, the second two representing the association, and the last representing the Department of Agriculture: David Starr Jordan, president of Leland Stanford University, *chairman;* Carroll D. Wright, president of Clark College; H. P. Armsby, director of the Pennsylvania State College Agricultural Experiment Station; W. H. Jordan, director of the New York State Experiment Station; Gifford Pinchot, forester, U. S. Department of Agriculture.

THE POPULAR SCIENCE MONTHLY

JUNE, 1907

THE PROBLEM OF AGE, GROWTH AND DEATH.[1]

BY CHARLES SEDGWICK MINOT, LL.D., D.Sc.,

JAMES STILLMAN PROFESSOR OF COMPARATIVE ANATOMY IN THE HARVARD MEDICAL SCHOOL.

I. THE CONDITION OF OLD AGE

THE subject of age has ever been one which has attracted human thought. It leads us so near to the great mysteries that all thinkers have contemplated it, and many are the writers who from the literary point of view have presented us, sometimes with profound thought, often with beautiful images connected with the change from youth to old age. We need but to think of two books familiar more or less to us all—that ancient classic, Cicero's *De Senectute,* the great book on age, one might almost say, from the literary standpoint, and that of our own fellow-citizen, my former teacher and professor at the Medical School, Dr. Holmes, who in his delightful 'Autocrat' offers to us some of his charming speculations upon age. From the time of Cicero to the time of Holmes numerous authors have written on old age, yet among them all we shall scarcely find any one who had title to be considered as a scientific writer upon the subject. Longevity is indeed a strange and difficult problem. Many of you doubtless have had your attention directed recently to the republished translation of Connaro's famous work and know how sensible that is, and as you read it you must have perceived how little in the practical aspect of the matter we have passed beyond the advice which old Connaro gave to us. And yet silently in the medical laboratories, and in the physiological and anatomical institutes of various universities, we have been gathering more accurate information as to what is the condition of persons who are very old.

[1] Lectures delivered at the Lowell Institute, Boston, March, 1907.

We know, first of all, from our common observation, that the very old grow shorter in stature. We see that they are not so tall as in the prime of life. The figures which have been compiled upon this subject are instructive, for they show that at the age of some thirty years the average height of men—these figures refer to Germans—is 174

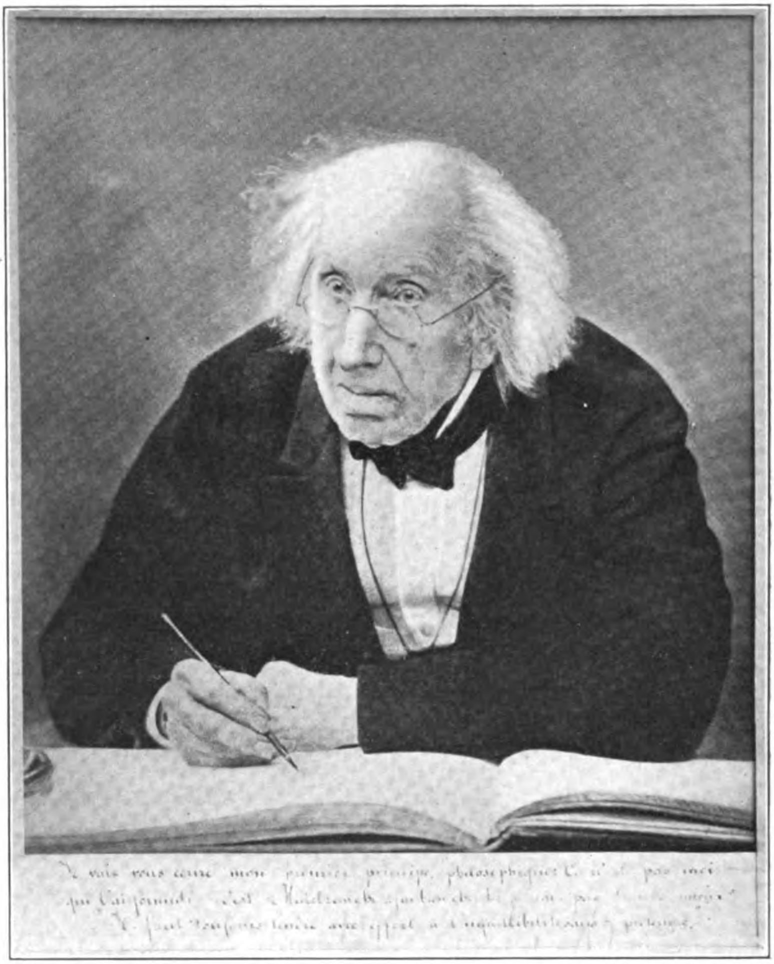


FIG. 1. PHOTOGRAPH OF CHEVREUL, taken on his one hundredth birthday. He was asked to write in an album and replied "Que voulez vous que j'écrive sur votre album. Je vais écrire mon premier principe philosophique, ce n'est par moi, qui l'ai formulé, c'est Malebranche "On doit tendre avec effort à l'infaillibilité, sans y prétendre." Chevreul was born Aug. 31, 1786 and died Aug. 9, 1889. For the privilege of using this portrait I am indebted to Dr. Henry P. Bowditch, to whom the interesting original belongs.

centimeters. It remains at that, however, only for a short period; then it decreases and at forty it is already less; at fifty decidedly less; and at sixty the change has become more marked; until at seventy years we find that the height has shrunk from 174 to 161. There it remains, or thereabouts, through the remainder of life, though there may be a small further diminution. This decrease in stature is due largely to the changes in the vertebral column. First of all there is a stoop. The vertebral column is, to be sure, never straight, but in old age it becomes more curved, and the result is a falling of the total stature. But this is not the chief cause, for in addition to this the

FIG. 2. PHOTOGRAPH FROM A CHILD AT BIRTH. The original is owned by Dr. H. P. Bowditch, by whose courtesy the present reproduction is published.

softer cartilages and elements of the spinal column become harder, change into bone, and as that change occurs they acquire a less extent and become smaller, and the result is that the vertebral column as a whole collapses somewhat and thus increases the diminution of height.

We find, as we look at the old, a great change to have come over the face. The roundness of youth has departed; the cheeks are sunken; the eyes have fallen far back; the lips are drawn in. All of these changes indicate to us, when we think upon them, the fact that there has been a certain shrinkage and shrivelling of that which is within and beneath the skin. Expressed in technical terms, we should call this an atrophy, and to anatomists the mere sight of the face of a very old person reveals at once this fundamental fact of an atrophy of the parts, an actual loss of some of their bulk, which is one of the most characteristic and fundamental marks of old age. The gait becomes shuffling, the foot is no longer lifted free from the ground, as the old man walks along. He does not rise upon his toes, but the sole of the foot is kept nearly flat and as he drags it cumbrously forward it is apt to strike upon the sidewalk. This indicates to the physiologist a lessened power in the muscles, a lessened control over the action of these muscles, an inferior coordination of the movements, so that there has been in the old man, judged by his gait alone, a physiological deterioration as well as an anatomical atrophy. You notice too his slow speech, often difficult hearing, and imperfect sight. All of these qualities show a loss, and we commonly think of the old as those who have lost most, who have passed beyond the maximum of development and are now upon the path of decline, going down ever more rapidly. One of the chief objects at which I shall aim in this course of lectures will be to explain to you that that notion is erroneous, and that the period of old age, so far from being the period of true decline, is in reality essentially the period in which the actual decline going on in each of us will be least. Old age is the period of slowest decline—a strange, paradoxical statement, but one which I hope to justify fully by the facts I shall present to you in this course. In the old person you note that there is in the mind some failure and also loss of memory—less mental activity, greater difficulty in grasping new thoughts, assimilating new ideas, and in adapting himself to unaccustomed situations. All this betokens again the characteristic loss of the old. And as we turn now from these outward investigations to those which the anatomist opens up to us, we learn that in the interior of the body, and in every organ thereof, the species of change which I have referred to as characteristic of the very old, is going on and has become in each part well marked. Let us first examine the skeleton. In youth many parts of the skeleton are soft and flexible, like the gristles and cartilages, which join the ribs to the breastbone, but in the old man they are replaced by bone. Bone represents an advance in organization, in structure, as we say, over the cartilage. The old man has in that respect progressed beyond the youthful stage; but that progress represents not a favorable change; the alteration in structure from elastic cartilage to rigid bone is physiologically disadvantageous, so that though the man has progressed in the organization or anatomy of his body, he has really thereby rather lost than gained ground. Indeed in the skeleton this principle of loss is already revealing itself. In the interior of the bones of the arms, of the legs, we find a spongy structure, bits of bone bound together in many different directions, as are the spicules or fibers in a sponge, and by being bound so together they unite lightness with strength. As you know a column of metal, if hollow, is stronger than the same amount of metal in the form of a rod. So with the bones. If they have this spongy structure, if their interiors are full of little cavities with intervening spicules acting as braces in every direction, then they acquire great strength with little material. Now in the old the internal spongy structure is dissolved away and there is left only a hard external shell. Partly on this condition depends the greater liability of the bones in the old person to break. If we examine the muscles we see that they have become less in volume, and when we apply the microscope to them we see that the single fibers on which the strength of the muscles depends have become smaller in size and fewer in number.[2] The muscle has actually lost; it is inferior, physiologically speaking, to what it was before. You remember how melancholy Jacques reminded us of this fact in speaking of the hose 'a world too wide for his shrunk shank.' His saying is justified by the loss of the muscles in volume and strength. The same phenomenon of atrophy shows itself in the digestive organs. Those minute structures in the wall of the stomach by which the digestive juice is produced, undergo a partial atrophy, in consequence of which they are less able to act; they are not so well organized, therefore, not so efficient as in earlier stages. The lungs become stiffened; the walls which divide off an air cavity from the neighboring air cavities do not remain so thin as in youth, but become thickened and hardened, and the vital capacity of the lungs, that is to say the capacity of the lungs to take in and hold air, is by so much lessened. The heart—it seems curious at first—is in the old always enlarged; but this does not represent a gain in real power. On the contrary, if we study carefully the condition of the circulation of the blood in the old, we find that the walls of the large blood-vessels, which carry the blood from the heart and distribute it over all parts of the body—vessels which we call arteries—have lost the elastic quality which is proper to them and by which they respond favorably to the pumping action of the heart. Instead they have become hard and stiff. We call this by a Greek term for hardening, sclerosis, and arterial sclerosis is one of the most marked and striking characteristics of old persons. Now when the arteries become thus stiffened, it requires a greater force

[2] This statement is the one currently accepted—but I have found, as yet, no exact investigation upon the relative size and number of the muscle fibers in old persons.

and greater effort of the heart to drive the blood through them, and in response to this new necessity, the heart becomes enlarged in an effort of the organism to adapt itself to the new unfavorable condition of the circulation established by age. But the power of the heart becomes inferior along with this hypertrophy or enlargement, and we see that in the old, in order to make up for the feebleness of the enlarged heart, it beats more frequently. In other words, the pulse rate in the old person increases.[3] We find, for instance, that at the time of

Age	Mean Frequency	Age	Mean Frequency	Age	Mean Frequency
0–1	134	13–14	87	25–30	72
1–2	111	14–15	82	30–35	70
2–3	108	15–16	83	35–40	72
3–4	108	16–17	80	40–45	72
4–5	103	17–18	76	45–50	72
5–6	98	18–19	77	50–55	72
6–7	93	19–20	74	55–60	75
7–8	94	20–21	71	60–65	73
8–9	89	21–22	71	65–70	75
9–10	91	22–23	70	70–75	75
10–11	87	23–24	71	75–80	72
11–12	89	24–25	72	80 and over	79
12–13	88				

birth the pulse rate is at the rate of 134 beats to a minute. It rises slightly during the first three months of infancy until at the end of the third month it reaches some 140 beats a minute; it soon falls off, however, and at the end of the first year it has sunk to 111; at five or six years it becomes 98, and at twenty-one years it has sunk to 71 or 72. There are thereafter certain minor fluctuations in the rate of the heart-beat with advancing age, but generally it may be said that this value of 72 beats a minute is characteristic of adult life. But when a person becomes eighty years old, it has been found that upon the average the rate of the heart-beat rises and becomes 79 a minute. Hence it is clear that though the heart is larger, it has to make a greater effort, that is to say a more frequent beat, in order to maintain the necessary circulation of the blood. We see also, as we go back to the anatomical examination of the body, that those important structures which we call the germ cells, upon which the propagation of the race depends, which present under the microscope certain clearly recognized characteristics by which they can be distinguished from all other cells of the body, that these germ-cells cease their activity altogether in the very old, and one of the great functions of life is thus blotted out altogether from the history of the individual.

Turning now to the yet nobler organs, especially the brain, we see

[3] My friend, Professor W. T. Porter, has had the kindness to compile the following table for me, showing the pulse frequency from one to eighty years. For the first two months after birth, the rate is about 130, after the third month 140. The fœtal rate is 135 to 140.

a curious change going on, a change of which old age presents to us the culminating record. In order to study the weight of the brain, it is necessary to compare people of the same size, for the size and weight of the brain depend somewhat upon the size of the individual. Now it has been discovered by careful examination of persons of similar size that the brain begins relatively early to diminish its weight. Thus in persons of a height of 175 centimeters, and over, of the male sex, it is found that in a period of from twenty to forty years the brain weight is 1,409 grams. But from forty-one to seventy years it has sunk to 1,363, and in persons of from seventy-one to ninety it has shrunk to 1,330. Women of corresponding size are not easily found, and a more average height for women is 165 centimeters; a woman of such a height is likely to have—among the white races, be it always understood—a weight of brain of 1,265 grams, at forty to seventy years a brain of 1,200, and at seventy-one to ninety years a brain of only 1,166 grams.[4] I give these figures because they show that there is no guessing, but a definite, positive knowledge, proving that soon after the maturity of life in the individual is reached, the shrinkage of the brain begins, and then continues almost steadily to the very end of life.

It is not only the anatomist, but it is perhaps almost equally the physiologist who gives us insight into the changes, which go on in the old. I spoke a few moments ago of the pulse rate, and of the change which that offers. At first sight it seems as if a greater pulse rate indicated an improvement, but if you recall the explanation which I have given you, you will acknowledge that this is by no means an acceptable interpretation, but that on the contrary the change is a clear mark of enfeeblement. In the respiration, also, we observe a like change. Here the comparison is not quite so easy as we should at first imagine, because there is a relation between the size of the individual and the respiration. The respiration, as you all know, frees the body from the products of combustion, particularly from that product which we know as carbon dioxide. The result of the combustion going on in the body (which in its end term appears to us as carbon dioxide expelled from the lungs) is to produce heat, to develop the necessary warmth for the maintenance of the proper tem-

[4] Ernst Handmann has recently published statistics on the growth of brain, based on measurements at the Leipzig Pathological Institute. See *Archiv f. Anat. u. Entwickelungsges.*, 1906, p. 1. The following summarizes his results:

Age	Brain Weight in Grams Male	Female
4– 6	1215	1194
7–14	1376	1229
15–49	1372	1249
50–84 (89)	1332	1196

perature of the body. Now in the very young the bulk of the body is not great, but the loss of heat is very great, and this perhaps can be most readily explained to you if you imagine that you hold in one hand a very small potato and in the other a very large potato, both of which have come at the same moment from the same oven, and that you have just started out for a cold winter drive. You all know, of course, that in a little while the small potato, though it was as hot as the large one at first, will have lost its heat, will no longer serve to keep the hand warm, but the other hand, in which the bulkier potato is held, in which the volume of the heat—we might so express it, perhaps—is correspondingly great, benefits by the retained heat a long time. Essentially similar to this is the difference between the child and the adult. The child loses heat with comparatively great rapidity—the old person at a comparatively slow rate. Hence it is necessary for the child to produce more warmth in order to keep up the natural normal temperature of the body. When, therefore, we find that in the old person the respiration is diminished, and that the production of carbon dioxide from the lungs is greatly lessened, we are not immediately to jump at the conclusion that the quality of physiological action has been debased—that we see here a sign of decrepitude. On the contrary, the change is the result of physiological adaptation, of suiting the performance of the body to its needs. This is one of the great wonders, one of the mysteries of life, of which we here have a sample, the constant adaptation of the means to the end. That which the body needs is done by the body. A child needs more warmth, and its body produces more; the old person needs less warmth, and his body produces less. How this is accomplished we are unable to say, but constantly we see evidence of this purposeful accommodation on the part of the body—what is called by the physiologists the teleological principle, the adâptation of the reaction of the body to its needs. There are innumerable illustrations of this, many of which are of course perfectly familiar to us, although perhaps we do not think of them as illustrations of this great law of nature. As, for instance, when we eat a meal, and the presence of food in the stomach calls into action the glands in the wall of the stomach by which the digestive juice is secreted. The juice is produced exactly at the time when it is needed. Innumerable, indeed, are the illustrations of this fundamental principle.

There is another class of phenomena characteristic of the very old which will perhaps seem a little surprising to you after the general tenor of my previous remarks. I refer to the power of repair. This, modern surgery especially has enabled us to recognize as being far greater in the old than we were wont to assume; and we know that there is a certain luxury, a certain excess reserve in the power of repair, and that we may go far beyond the ordinary necessities of our life in our demands upon our organism, and still find that our body is capable of making the necessary response. Ordinarily the amount of blood which we require is moderate in amount—moderate in the sense that the destruction of the blood continually going on in the body is not a very rapid process; but if, through some accident, a person loses a large quantity of blood then by one of these teleological reactions of which I have spoken, the production of new blood is increased, the loss is soon made up, and we discover that the blood, so to speak, has been repaired. Or when a little of the skin is lost, it quickly heals over. That again is due to the power of repair. Ordinarily so long as the skin remains whole that power is not called into action, but if a wound comes, then the regenerative force resident always in the skin, but inactive, comes into play and produces the mending which is such a comfort. So in old people, some of this luxury of reparative power persists, so that they can recover from wounds in a far better way than we should imagine if we judged them only by the general physiological and anatomical decline exhibited throughout all parts of the body. Some of the luxury of repair comes in usefully in old age.

Now if we consider all these changes in the most general manner, we perceive that they are clearly of one general character; they imply an alteration in the anatomical condition of the parts; but it is an alteration which does not differ fundamentally in kind from the alterations which have gone on before, but it does differ in the extent and in part in the degree to which these alterations have taken place. When the elastic cartilaginous rib becomes bony, nothing different is happening from that which happened before, for there was a stage of development when the entire rib consisted of cartilage, and in the progress of development toward the adult condition that cartilage was changed gradually into bone, thus producing the characteristic, normal, efficient bony rib of the adult. When old age intervenes, the change of the cartilage into bone goes yet further, but it progresses in such a way that it is no longer favorable, but unfavorable. We have then in this case a clear illustration of a principle of change in the very old which is, I take it, perhaps sufficiently well expressed by saying that the change which is natural in the younger stage is in the old carried to excess. But there is in addition to this, something more, of which I have already spoken, namely the atrophy of parts, and by atrophy we mean the diminution, the lessening of the volume of the part. There is a partial atrophy of the brain in consequence of which that organ becomes smaller; there is an extensive atrophy of the muscles in consequence of which their volume is diminished, and their efficiency decreased. Atrophy is preeminently characteristic of the very old, and we see in very old persons that it becomes each year more and more pronounced. Indeed, it has been said recently by Professor Metchnikoff, a distinguished Russian zoologist, now connected with the

Pasteur Institute in Paris, some of whose publications many of you have doubtless read, that his conception of the nature of senility, of old age, could best be expressed in a single word, atrophy. "On résume la senilité par un seul mot: atrophie."[5] That is his estimate of old age. But that is not the only estimate of old age which has been made up to the present time. We find one, which is much more prevalent, is that which connects it with the condition of the arteries. Indeed, Professor Osler has written this sentence—"Longevity is a vascular question, and has been well expressed in the axiom that a man is only as old as his arteries." Now these are medical views, not biological, and you will find that there is a very extensive literature dealing with old age in man based upon the conception that old age is a kind of disease, a chronic disease, an incurable disease. Medical writers have put forward various conceptions giving a medical interpretation of this disease. That to which I just referred is the favorite one, the one you are most likely to hear from physicians to-day—namely, the theory of arterial sclerosis, that the hardening of the walls of the arteries is the primary thing; it interferes with the circulation, the bad circulation interferes with the proper working of every part of the body, and as the circulation becomes impeded, various accessory results are produced in the body in consequence. It is brought to a lower or more diseased condition than before. And so they interpret sclerosis of the arteries as the primary thing, because they can trace so many alterations in the old which resemble diseased alterations, to these natural changes in the arteries by which they acquire hardened and inelastic walls, which prevent the proper response of the artery to the heart beat, upon which the normal healthy circulation largely depends. Another interpretation, very curious and interesting, is that which has been recently offered by the same Professor Metchnikoff whom I have just mentioned. He has written a book upon the 'Nature of Man,' translated in 1903, and published in this country. It is an interesting book. It gives a most attractive picture, incidentally, of Metchnikoff himself, a man of pleasantly optimistic temperament, but a man thoroughly imbued with the spirit which has so often been attributed to contemporary scientific men, of cold, intellectual regard towards everything, towards life, towards man, towards mystery. For him mysteries of all sorts have little interest. Those things which are mysterious are beyond the sphere of what can hold his attention. He must reside in the clear atmosphere of definite, positive fact. This mental bias is shown in his book. He reviews in a happy way various past systems of philosophy; he describes various religions; and he points out his reasons for thinking that all of these are insufficient, that there is no satisfaction to be derived from any of the ancient

[5] *L'Année biologique*, Tome III., p. 256, 1897.

philosophies or from any of the great world religions. Nevertheless he is an optimist. He has noticed as a result of his meditations upon the arrangements within our bodies that we suffer very much from what he calls *disharmonies,* by which he means imperfect adaptations of structures within us to the performance of the body as a whole. He mentions various instances of such disharmonious parts. They do not seem to me quite so imposing as apparently they do to him, for many of his disharmonies are based upon the fact that we do not know that a certain structure or part has any useful rôle to play in the body. But I am inclined to suspect that in many cases it is only because we are ignorant; the list of useless structures in the human body was a few years ago very long; it has within recent years been greatly shortened, and we should learn from this experience a caution in regard to judging about these things, which, I think, Professor Metchnikoff has failed to exert duly in forming his opinions on these disharmonies. Now among the disharmonies which he recognizes is that of the great size of the large intestine, which is of such a caliber that a considerable quantity of partially digested food can be retained in it at one time. When such food is retained in the intestine, it may undergo a process of fermentation. There are many sorts of fermentation, and some of them produce chemical bodies which are injurious to the human organism. Bacteria, which will cause fermentation of this sort, do actually occur in the human intestine. Metchnikoff thinks that, as we grow old, this tendency to fermentation increases. Now the bodies produced by fermentation, the chemical bodies, I mean, get into our system and poison us. The result of the poisoning is that the native capacities of the various tissues and organs of the body are lowered, as happens in a man 'intoxicated.' All parts of a man may be poisoned, not necessarily always with alcohol, but with many other things as well, and such a poisoning Professor Metchnikoff assumes to result from intestinal fermentation. Moreover, he has further observations, which lead him to the idea that certain cells go to work upon the poisoned parts and do further damage. The cells in question are minute microscopic structures, so small that we can not at all see them with the naked eye, but which have a habit of feeding in the body upon the various parts thereof whenever they get a chance. Cells of this sort go by the scientific name of phagocytes, which is merely a Greek term for 'eating cells.' The phagocytes, for instance, devour pigment in the hair, and in old persons the production of white hair has resulted from the activity of phagocytes which have eaten the pigment which should have remained in the hair and kept its color. But the pigment of the hair is not the only thing they will attack; they will make their aggressive inroads upon any part of the body; and Professor Metchnikoff has advanced the theory that old age consists chiefly in the damage which is done by phagocytes to poisoned parts of the body, the poisoning being due to the fermentation in the large intestine. Now it has been observed by some of the German investigators of these matters that the presence of lactic acid interferes with this fermentative process as it goes on in the intestine. Lactic acid, as its name implies, is the characteristic acid which occurs in milk when it becomes sour. An Italian friend of Professor Metchnikoff tried drinking some sour milk with the idea of stopping the fermentation in the intestine, and so putting an end to the deleterious change, and he believes in the short time that he tried it that it did him good—quite, you see, in the way of a patent medicine. Professor Metchnikoff, on this basis, has recommended, in his book on the 'Nature of Man,' the regular drinking of sour milk, in the hope apparently that that will postpone senility, and will leave us our powers in maturity long beyond that period when we at present reach the fullness of our vigor, and advance the period of time when the changes of the years put us out of court. He regards this as an optimistic substitute for the various forms of philosophy and religion which many millions of people have found helpful in life, and certainly it is the cheapest substitute which has ever been seriously proposed.

There is another writer who, though having a German name, is in reality a Russian, Professor Mühlmann. He has another theory in regard to the fundamental nature of senility. He takes such instances as that which I spoke of, of respiration in connection with the production of warmth in the child's body and in the body of the adult, and finds that the diminution of the surface in proportion to the bulk of the body is characteristic of the old, and he concludes that we become old because we do not have proportionately surface enough left. His view implies, apparently, that if we could keep ourselves more or less of the stature of pygmies we should be healthier and better off. I confess these theories, and many others which I might enumerate to you, seem to me to be somewhat fantastic—odd rather than valuable. Yet they all spring from this one common feeling, which is, I believe, a sinister influence upon the thought of the day, in regard to the problem of age—they spring from the medical conception that age is a kind of disease, and that the problem is to explain the condition as it exists in man. Now that is precisely what I wish to protest against. What I hope to accomplish in these lectures is to build up gradually in your minds some acquaintance with the fundamental and essential changes, which are characteristic of age and in regard to which we have been learning something during the last few years—I might almost say only within recent years—and by means of this exposition to give you a broader view and a juster interpretation of the problem. I hope, before I finish, to convince you that we are already able to establish certain significant generalizations as to what is essential in the change from youth to old age, and that in consequence of these generalizations, now possible to us, new problems present themselves to our minds, which we hope really to be able to solve, and that in the solving of them we shall gain a sort of knowledge, which is likely to be not only highly interesting to the scientific biologist, but also to prove, in the end, of great practical value. Surely we can not hope to obtain any power over age, any power over the changes which the years bring to each of us, unless we understand clearly, positively and certainly, what these changes really are. I think you will learn, if you do me the honor to follow the lectures further, that the changes are indeed very different from what we should expect when we start out on a study of age, and that the contributions of science in this direction are novel and to some degree startling. We can begin to approach this broader view of our subject if we pass beyond the consideration of man.

If we turn from man to the animals which we are most familiar with, the common domestic quadrupeds, we see that they undergo a series of changes not very dissimilar to those which man himself must pass through. An old horse, an old dog, an old cat, shows pretty much the same sort of decrepitudes which characterize old men. But when we pass farther down in the scale to the fishes, or even to a frog, we discover great differences. Do you think you could tell a frog when it is old by the way it walks—for it never walks—or a fish by the amount of hardening of the lungs, when it has none? Yet the lack of lungs is characteristic of the fish. And what becomes of the theory of arterial sclerosis when we go still lower in the animal kingdom, towards its lowermost members, and find creatures which live and thrive and have lived and thriven for countless generations, yet have no arteries at all? They, of course, do not grow old by any change of their arteries. But when we come to study these various animals more carefully, we learn that in them the anatomical and physiological features which I have indicated to you in my description of the changes in the human being, are paralleled, as it were, by similar changes; but only by similar, not by identical, changes. If we examine the insects, for instance, we see that in an old insect there is a hardening of the outer crust of the body which serves as a shell and a skeleton at once. That hardening increases with the age of the individual. We can see in the insect a lessening development of the digestive tract, and we can see—it has been demonstrated with particular nicety—a degradation of the brain. Insects have a very small brain, but when a bumblebee, or a honeybee, grows old, as he does in a few weeks after he acquires his wings, we see that the brain actually becomes smaller, and not only that, but as I shall be able to demonstrate to you with the lantern in the next lecture, the elements which build up the brain have each of them become smaller and the diminution in the size of the brain is due in part to the shrinkage of the single microscopic constituents. There is another point of resemblance. We find that when one of the better parts of the body undergoes an atrophy, it becomes not only smaller, but its place is to a certain extent taken by the inferior tissues—especially by those which we call comprehensively the connective tissues, which might perhaps be best described to a general audience as that which is the stuffing of the body and fills out all the gaps between the organs proper. In consequence of performing this general function, they are very properly called connective tissues, since they connect all the different organs and systems of organs in the body together. Now in every body there is a continual fighting of the parts. They battle together, they struggle, each one to get ahead, but the nobler organ, generally speaking, holds its own. There are early produced from the brain the fine bundles of fibers which we call the nerves, which run to the nose, to the tongue and to the various parts of the body. When these appear all the parts of the body are very soft. Afterwards comes in the hard, and, we should think, sturdy bone, but never, under normal conditions, does the bone grow where the nerve is. The nerve, soft and pulpy as it seems, resists absolutely the encroachment of the bone, and though the bone may grow elsewhere, and will grow elsewhere the moment it gets a free opportunity, it can not beat the soft delicate nerve.[6] Similarly we find that the substance which forms the liver is pulpy, very delicate. Those of you who have seen fresh liver in the butcher's shop know what a flabby organ it is, and yet though it is surrounded by the elements of connective tissue, which with great zest and eagerness produce tough fibers, it never gives way to them. The connective tissue is held back by the soft liver and kept in place by it. The liver is, so to speak, a nobler organ than the connective tissue and holds sway ordinarily; but in old age, when the nobler organs lose something of their power, then the connective tissue gets its chance, grows forward and fills up the desired place, and acquires more and more a dominating position. We can see this alike in the brain of man and in the brain of the bee. That which is the nervous material proper, microscopic examination shows us to be diminished everywhere in the old bee and in the old man, and the tissue which supports it, which is of a coarser nature and can not perform any of the nobler functions, fills up all the space thus left, so that the actual composition of the brain is by this means changed. There is, you see, therefore, during the atrophy

[6] The nerve fibers of the olfactory membrane arise very early in the embryo and form numerous separate bundles. Later the bone arises between the bundles, for each of which a hole is left in the osseous tissue, so that the bone in the adult has a sieve-like structure, and hence is termed the cribriform plate. It offers a striking illustration of the inability of hard bone to disturb soft nerve fibers.

of the brain, not only a diminution of the organ as a whole, but there is the further degradation which consists in the yielding of the nobler to the baser part, if I may so express myself. That, you recognize, necessarily implies a loss of function. The brain can not under senile conditions do the sort of fine and efficient work which it could do before. Now if we go on from insects to yet lower organisms, we see less and less appearing of an advance in organization, of correlated loss of parts, and when we get far enough down in the scale, senescence becomes very vague. The change from youth to old age in a coral or in a sponge is at best an indefinite matter.

I should like, did the length of the course permit, to enlarge greatly upon this aspect of the question, and explain to you how it is that as the organism rises higher and higher in the scale, old age becomes more and more marked, and in no animal is old age perhaps so marked, certainly in no animal is it more marked, than in ourselves. The human species stands at the top of the scale and it also suffers most from old age. We shall learn, I hope, more clearly later on in the course of these lectures, that this fact has a deeper significance, that the connection between old age and advance in organization, advance in anatomical structure, is indeed very close, and that they are related to one another somewhat in fashion of cause and effect; just how far each is a cause and how far each is an effect it would perhaps be premature to state very positively; but I shall show you, I think in a convincing way, that the development of the anatomical quality, or in other words of what we call organic structure, is *the* fundamental thing in the investigation of the processes of life in relation to age. We can see it illustrated again very clearly indeed when we turn to the study of plant life, for plants also grow old. Take a leaf in the spring. It is soft as the bud opens. The young leaf is delicate. It has a considerable power of growth. It expands freely, and soon becomes a leaf of full size. Then comes the further change by which the leaf gets a firmer texture; the production of anatomical quality in the leaf, so to speak, goes on through the summer, and the result of that advance in the anatomical quality is that the delicate, youthful softness and activity of the leaf is stopped. It can not grow any more; it can not function as a leaf properly any more. The development of its structure has gone too far and the leaf falls and is lost, and must be replaced by a new leaf the next year. When we examine the changes that go on in any flowering plant, we observe always that there is this production of structure, and then the decay, the end or death. At first structure comes as a helpful thing, increasing the usefulness of the part, and then it goes on too far and impairs the usefulness, and at last a stage is produced in which no use is possible any longer—the thing is worthless. It is cast away in the case of the plant life; and this casting away of the useless is a thing not by any means confined to plants; it occurs equally in ourselves all the time; at every period of our life we have been getting through with some portion of our body; that portion acquired a certain organization, it worked for us awhile, and then being done with it, we threw it away because it was dead. Very early in the history of every individual there was a production of blood, and then followed the destruction of some of the blood corpuscles and their remains were used for various purposes. The pigment which is in the liver comes from the destroyed blood corpuscles, and it is believed that the pigment which colors the hair is derived from the same source. The blood corpuscles contain a material which when chemically elaborated reappears as the deposit which imparts to the hairs their coloration. You, of course, are all familiar with the loss of hair. It occurs to everybody, but did you ever think that it means that the hair which has lived has died, and that that hair which was a part of you has been cast off? That is what the loss of hair means to the biologist—the death of a part and the throwing away of it, and it is typical of what is going on through the body all the time. It occurs in the intestines, where the elements which serve for purposes of digestion are continually dying and being cast off. The outer skin is constantly falling off and being renewed, and that which goes is dead. In every part of the body we can find something which is dying. Death is an accompaniment of development; parts of us are passing off from the limbo of the living all the time, and the maintenance of the life of each individual of us depends partially upon the continual death going on in minute fragments of our body here and there.

Our next step in this course of lectures will carry us into the microscopic world, and with the aid of the lantern at the next lecture I shall hope to demonstrate to you a little of the microscopic structure of the body and of the general nature of the change, which exhibits itself in the body from its earliest to its latest condition. With such knowlege in our minds, we shall be able next to study some of the laws of growth. We shall gain from our microscopic information a deeper insight into some of the secrets of the changes, which age produces in the human body.

THE PROGRESS OF OUR KNOWLEDGE OF THE FLORA OF NORTH AMERICA

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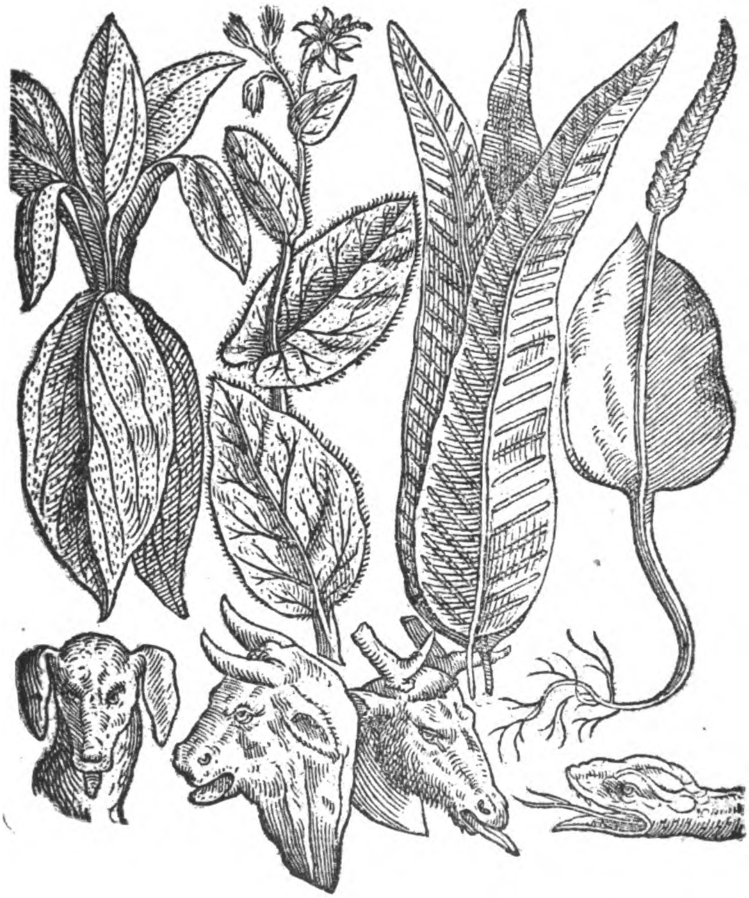
COLUMBIA UNIVERSITY

WHATEVER may be the avenue of approach to the subject of botany as a science, whether we work out the details of the development, maturation and division of the elements within the single cell, or seek to trace the race history through the detailed development of a single organism from egg to egg again, or whether we approach it through either the mutations or the variations of a single species, the last problem of investigation as well as the first will bear directly on the question: What are the relations of plants to each other in the natural system of classification? In this broader sense all botanists, whether they are only cytologists, whether they deal with the fascinating problems of embryological development, whether they are field ecologists, or finally whether they are *just botanists* pure and simple, because they love the things of nature and can not help being botanists if they are anything at all—all these are systematic botanists, even though some of them appear to others as unsystematic, when their wilder flights into the realm of the imagination cause them to become mere theorists with no stable foundation in real facts.

So multifarious have become the problems that have entered into the study of botany in these latter days, that it is sometimes difficult for a layman, brought up in the ancient conception of botany as the mere study of flowers, to understand the breadth of scientific training involved in the development of a modern botanist; in fact, it is often a difficult problem for specialized botanists themselves to understand all the bearings of the highly specialized work of some of their fellows, and the research student of to-day soon finds himself pushing out into ground still unbroken, which his predecessors may have had glimpses of from afar, but never really entered to occupy and cause it to yield its fruits. I am speaking here of *real students,* not of those sutlers and train followers that swarm about the rear of every respectable army, and often try to pass themselves off for the real rank and file. Of that large array who pursue botany as far as light comedy, because somebody wrote 'How to know the dandelions in their lair' and roll such polysyllables as *Taraxacum* and *Leontopodium* glibly from their tongues in order to impress the unwitting citizen of their accomplishments, we have

HASCE *plantulas tibi proponimus, animalium linguas imitantes; cynoglossum canis linguam exprimit; in mox subsequenti, buglossum bouinam; post, elaphoglosson ceruinam; postremo, ophioglosson serpentinam, insuper apparentibus vna e regione animalium nominatorum linguis: propositum spectaculum intuitor, & contemplator.*



plo lin-

Fig. 1. Fac-simile of a page of Porta's work (1591) showing similarities in plants to parts of animals, hound's-tongue (*Cynoglossum*), bugloss (*Anchusa*), hart's-tongue fern (*Phyllitis*), and adder's-tongue (*Ophioglossum*). It is interesting to note that two of Porta's names are still in use in a scientific sense, a third in a popular sense, while the fourth (*Elaphoglossum*) was later taken up for a genus of ferns distinct from the hart's-tongue of Europe.

ben/darzů haben die alten Sewmist mit Menschen harn der
wurtzel gegossen. Der harn aber ist nutz zů allē Krancken wur

FIG. 2. Fac-simile of an illustration of Bock (1587) showing the apple-tree, known variations of its fruit including the 'sheep's nose (gilliflower), death's head and the serpent,' alluding of course to its supposed relation to the fall of man.

little to say; they are of a class so foreign, that though often loud-spoken, as foreigners sometimes become, they are not botanists to the manor born and never will become anything but sutlers.

Far back in the early centuries, men looked at plants largely from the standpoint of utility, and every plant not useful for food was supposed to have some virtues of the healing sort that made it useful medicinally. Doubtless many of these notions came from the real presence of some remedial virtues, for many plants of the pharmacopeia were known to the ancients; but in attributing so many virtues to so many harmless succulents, one wonders sometimes just how far the principle of dishonest graft entered into the dealings of the old simplers with their nostrums. At any rate, volume after volume of herbals was published, illustrating many common and often rare plants, and sometimes in a very realistic way their real or supposed effects on the human system. A few illustrations of these from among the works of the fifteenth, sixteenth and seventeenth centuries may not be amiss. Porta in 1591 published page after page of illustrations showing fancied resemblances between plants and all sorts of human and animal parts, and often the discovery of such a similarity to some part of the human frame led to the unwarranted conclusion that the Almighty thus pointed out to mortals a definite specific in the plant thus possessing this resemblance. One of the favorites among these early medicinal frauds was the supposition that because the delicate stems and branches of the maidenhair fern were really hair-like, one had only to steep them in water to supply an effective hair tonic which, for growing copious and lustrous hair and preventing incipient baldness, would place the danderines and herpicides of these degenerate days sadly in the shade!

Many of these early herbals were printed in Latin as the standard language of medicine and learning generally, but later they were printed in the vernacular of the country in which they were written, and often something symbolic of the particular plant they illustrated was added to appeal more strongly to the mind of the reader. We give an illustration from one of the larger herbals of the sixteenth century, that of Hieronymus Bock (1587) in old German, depicting with the apple the serpent and death that was supposed to have been brought into the world by eating this really delicious fruit. We also give a quotation from Parkinson (1640), whose English herbal is perhaps the most complete compendium of the folk-lore of plants and all the other old dames' fancies concerning the English flora that was ever written. Here every plant description and history is followed by an account of its 'virtues,' often set forth in exaggerated terms.

Concerning *Salvinia natans,* which he describes and figures as '*Lens palustris latifolia punctata,*' Parkinson says:

'The Vertues'

It is cold and moist as *Galen* saith in the second degree, and is effectuall to helpe inflammations, and Saint *Anthonies* fire, as also the Goute, either applied by it selfe, or else in a pultis with barlie meale: it is also good for ruptures in young children. Some saith *Matthiolus* do highly esteeme of the destilled water of the herbe against all inward inflammations and pestilent feavers, as also to helpe the rednesse of the eyes, the swellings of the cods, and of the brests before they be growen too much, for it doth not weakely repell the humours: the fresh herbe applied to the forehead, easeth the paines of the headache comming of heate. Duckes do greedilie devoure it, and so will Hens if it be given them mingled with branne.

The progress of world exploration that followed the discovery and colonization of the East and West Indies and the mainland of the then dark continents of Asia and America brought to European gardens many unusual plants which later writers, particularly those of the eighteenth century, carefully described, often with elaborate illustrations, in publications emanating from these public and private gardens of the old world. We give a copy of the title-page of the first work of this kind which describes and figures American plants.

JAC. CORNUTI

DOCTORIS MEDICI

PARISIENSIS

CANADENSIUM PLANTARUM,

aliarumque nondum editarum

HISTORIA.

* * * * *

PARISIIS,

M. DC. XXXV.

CUM PRIVILEGIO REGIS.

It will be noted that this bears the date of 1635, only fifteen years after the landing of the Pilgrim fathers, and is primarily a history of the plants of Canada which was then the synonym of North America. A sample illustration will give one of Cornut's figures of one of our common spring plants, and its name, *Asaron canadense*, the same it still bears, will show at a glance that the binomial system of naming plants was not only not invented by Linnæus, but was in common use almost a hundred years before he published a single line on botany, and more than seventy years before he was born! Our common maidenhair, the bulb-bearing fern (also illustrated here), the

Canadensium Plant. Historia. 25

ASARON CANADENSE.

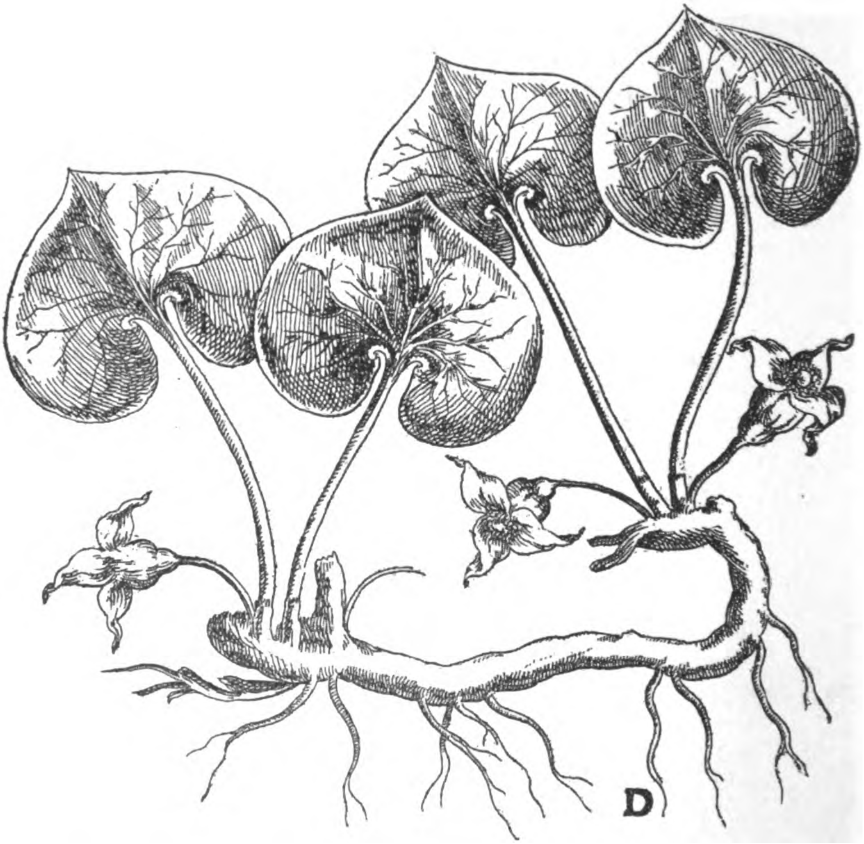


FIG. 3. Fac-simile of illustration by Cornut (1635) of wild ginger (*Asarum canadense*). (Plate by courtesy of *The Plant World*.)

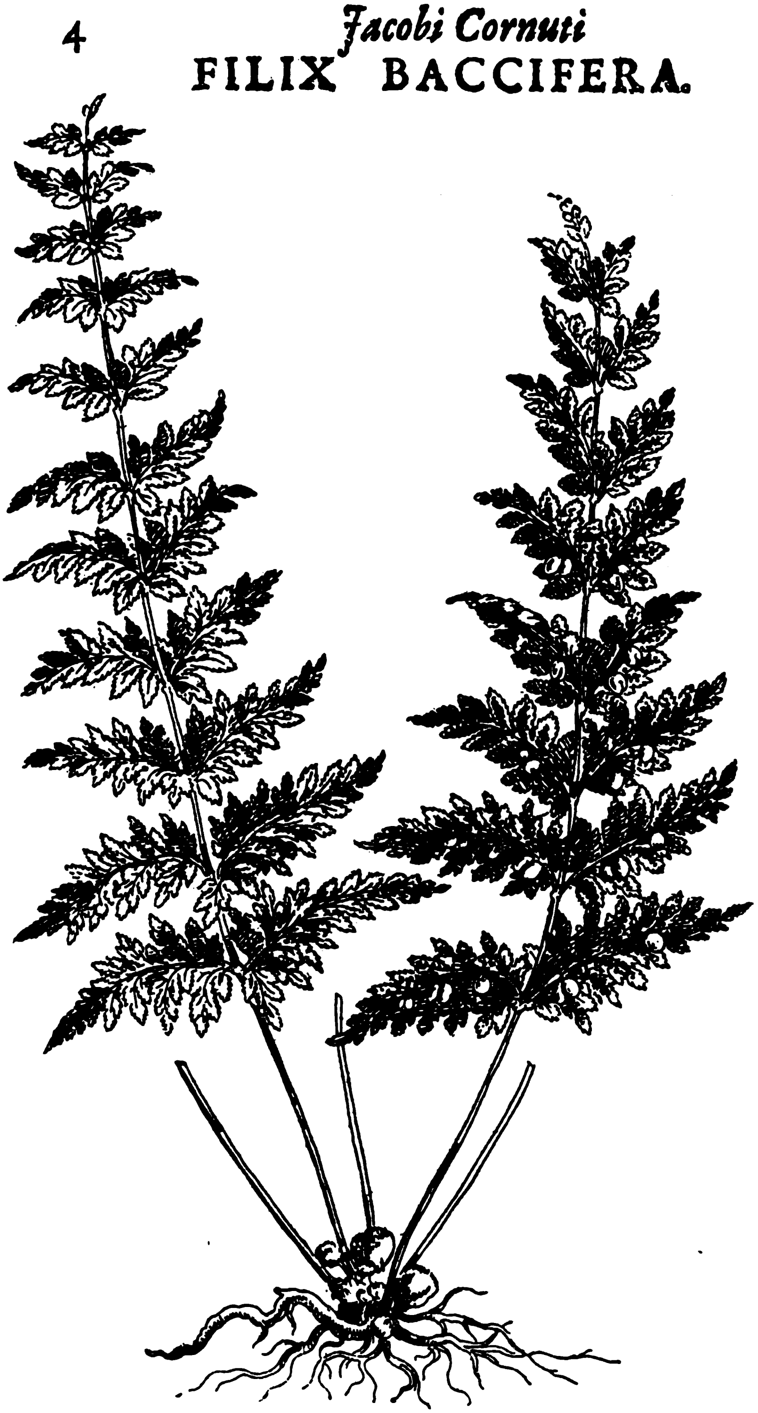


Fig. 4. Fac-simile of illustration by Cornut (1635) of the bulb-bearing fern (*Felix bulbi. fera*). This with a plate of the common maidenhair in the same work formed the first published illustrations of American ferns.

false solomon's seal, the yellow bellflower, the Dutchman's Beinkleider and many other common American plants are similarly illustrated in this quaint old volume.

The early days are famous for certain quaint and interesting collectors of curios brought in by sea-captains and other early sailors from the four corners of the earth. Among these old-time naturalists were Petiver and Plukenet, who filled huge folios with miscellaneous illustrations of plants and animals from all over the world.

We reproduce here a single plate from the latter which is just now interesting because it figures a fern peculiar to the caves of Bermuda, and named from that circumstance (*Polypodium speluncæ* L.), but one which jugglers of the past generation of botanists have placed outside its proper species, genus and even tribe, and have attributed to nearly all parts of the tropical world except, alas, the very island from which it originally came! We should mention in this connection the 'Natural History of Jamaica,' by Sir Hans Sloane, whose plates are typified by his Jamaica herbarium over two hundred years old, but still in a splendid state of preservation at the British Museum; and also the work of Charles Plumier, who laid the foundations of West Indian botany as early as 1703, and whose works are of vital importance to-day in our study of the flora of our tropical islands. Later on Mark Catesby explored the Bahamas and Carolina and published with elaborate folio plates many of the characteristic plants and animals of those little explored regions.

The conception of a plant genus as a coherent group of species apparently became crystallized by Tournefort, who published his *Institutiones* in 1700; in this work he gave many illustrations accompanied by descriptive text in this first *genera plantarum*. Tournefort, like many modern botanists, knew mainly the higher plants, and it was reserved for Micheli (1729) to open the eyes of his fellow students to the genera of fungi, hepatics and lichens, and to Dillen (1744) to give us a foundation for the study of the mosses and the lycopodiums. The plates of Dillen's *Historia Muscorum* show what he knew about mosses with a hand lens a hundred and sixty-three years ago, and we give a sample plate from Micheli showing the symmetric rows of slime molds of the genera *Stemonitis* and *Arcyria* of modern botanical jargon. When the next generation, less hurried and temporizing than the present, comes to take up the question of plant nomenclature in a really rational fashion, these names of Tournefort and Micheli will be restored to their rightful place in a system that makes priority of publication its corner stone!

All this vast array of early botanical literature, ranging from ponderous folios with plates, often colored by hand, down to miniature Elzevir editions, with typography that puts the modern imitations to

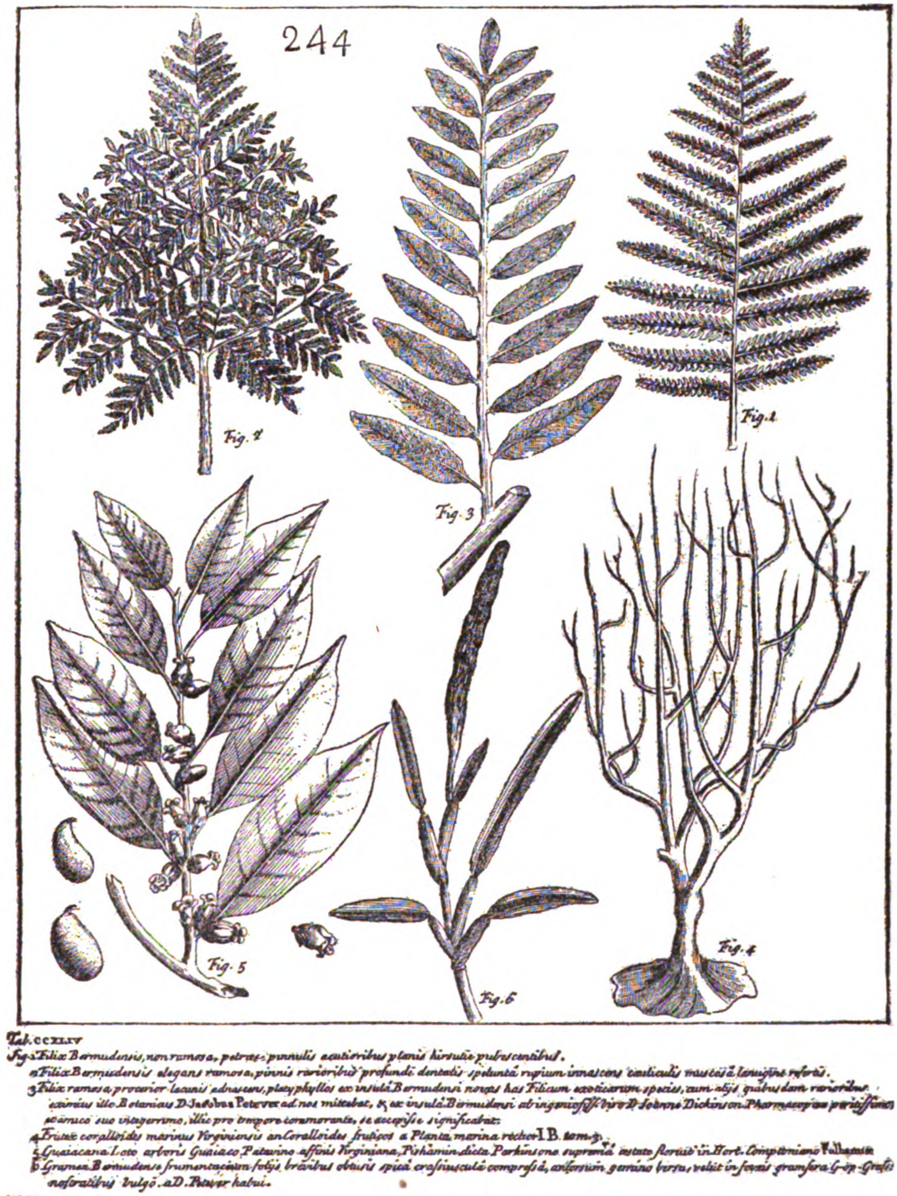


FIG. 5. Copy of a plate from Plukenet showing a medley of illustrations. His Fig. 2 is the cited type of *Polypodium speluncæ* L., a species of *Dryopteris* still growing in the Bermuda caves. The name has wrongly descended to *Davallia speluncæ*, a member of a genus and tribe of ferns never native to Bermuda. (Slightly reduced.)

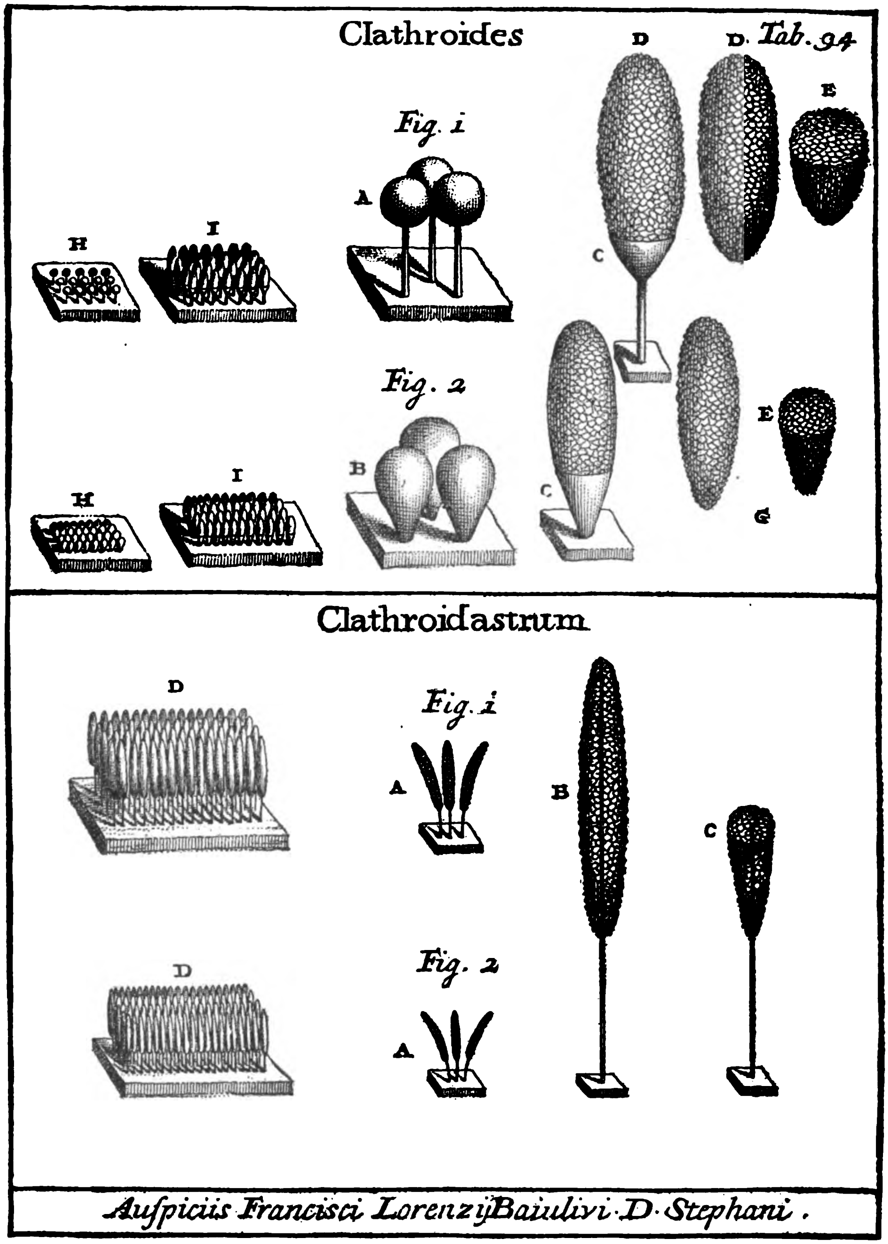


FIG. 6. Copy of a plate from Micheli (1729) showing the earliest myeetozoa (myxomycetes) figured under a definite generic name. (Slightly reduced.)

shame, finally became so voluminous and so lacking in a system that it must needs be put in order. This was accomplished by Linnæus, who proved in his 'Species Plantarum' of 1753 that the indexer is sometimes as important as the real discoverer, and this may give encouragement to the often unthanked class of librarians and bibliographers without whose work our best efforts would often be squandered in fruitless searchings of the literature of the past. Since this work of Linnæus has been fixed upon as the initial point of priority of names, it is well to pause long enough to see how a page of it really looks. Like many of the standard books even of recent descriptive botanical literature it is all in Latin, which goes to prove that in botany, at least, Latin is not a dead language. I venture the assertion that as much Latin is read daily within the walls of the museum of the New York Botanical Garden as in any building in New York city, not excepting the departments of Latin in its colleges.

But space forbids us to follow farther the general development of our knowledge of the world's flora as depicted in the various works emanating from the geniuses of the generations. We can only mention in passing a few of the landmarks that stand as beacons along the course of systematic botany. Here is an early one at Berlin where the brilliant Willdenow, though dying at forty-seven, gave us a rational 'Species Plantarum,' the fourth since Linnæus and the first that really described plants from their characters. Here stands another on Lake Geneva where Augustin, most brilliant of four generations of De Candolle botanists, commenced the 'Prodromus,' which was the next great attempt to set in order our increasing knowledge of the world's vegetation. Here is a third at Kew, where George Bentham actually grappled with death and forced it back, that he might complete his masterly 'Genera Plantarum.' And here is a more recent, wide-reaching, and more useful if less brilliant beacon again set up at Berlin under the leadership of the Bismarck of German botany—who, though Regierungsrath, modestly and democratically subscribes himself, 'A. Engler.'

Turning now to the real subject in hand, let us take a glimpse at the progress of our knowledge of the American flora. It can be only the merest glance because of the natural complexity of the subject; we must look at landmarks here and there, and note only the general trend of a few of its more salient features.

Among the early observers of plants in the American provinces was John Clayton, of Virginia, for whom our little spring-beauty is named. He made collections of the plants noted in that province and sent them to Gronovius, who published a 'Flora Virginica' in 1739—a work known to Linnæus and constantly cited as his authority for American plants. Gronovius' plants are still preserved in the British

Chara caulibus aculeatis. *Hort. cliff.* 477. *Roy. lugdb.* 214.
Chara major, caulibus ſpinoſis. *Vaill. act.* 1719. *p.* 18. *t.* 3. *f.* 3.
Equiſetum ſ. Hippuris muſcoſus ſub aqua repens. *Pluk. alm.* 135. *t.* 193. *f.* 6.
Habitat in Europæ maritimis.

4. CHARA caulium articulis inermibus diaphanis ſuperne latioribus. *It. gotl.* 215. *Fl. ſuec.* 995. *flexilis.*
Chara transfluens minor flexilis. *Raj. angl.* 3. *p.* 133.
Habitat in Europæ *maritimis.*

TREMELLA.

1. TREMELLA ſeſſilis membranacea auriformis fulva. *Fl. ſuec.* 1017. *Juniperina.*
Byſſus gelatinoſa fugax, junipero innaſcens. *Fl. lapp.* 531.
Habitat in Juniperetis *primo vere.*

2. TREMELLA plicata undulata. *Fl. ſuec.* 1018. *Nostoc.*
Tremella terreſtris ſinuoſa pinguis & fugax. *Dill. muſc.* 52. *t.* 10. *f.* 14.
Byſſus gelatinoſa fugax terreſtris. *Fl. lapp.* 530.
Linkia terreſtris gelatinoſa membranacea vulgatiſſima. *Mich. gen.* 126. *t.* 67. *f.* 1.
Noſtoc paracelſi. *Act. pariſ.* 1708. *p.* 228.
Habitat in Pratis *poſt pluvias.*

3. TREMELLA ſeſſilis membranacea auriformis cinerea. *Fl. ſuec.* 1119. *Auricula.*
Agaricum auriculæ forma. *Mich. gen.* 124. *t.* 66. *f.* 1.
Fungorum perniciorum genus 1. *Cluſ. hiſt.* 2. *p.* 276.
Habitat ad Arbores *putridas.*

4. TREMELLA frondibus erectis planis: margine criſpo lacinulato. *Fl. ſuec.* 1020. *Lichenoides.*
Lichenoides pellucidum, endiviæ foliis tenuibus criſpis. *Dill. muſc.* 143. *t.* 19. *f.* 31.
Lichen terreſtris membranaceus mollior fuſcus. *Mich. gen.* 26. *t.* 38.
Muſco fungus terreſtris minor fuſcus, foliis e latitudine crenatis muſco innaſcens. *Moriſ. hiſt.* 3. *p.* 632. *ſ.* 15. *t.* 7. *f.* 4.
Habitat in Muſcis, *locis umbroſis ad montes.*

FIG. 7. Fac-simile of a page of Linnæus's 'Species Plantarum' (1753). It is interesting to note that none of Linnæus's species of *Tremella* belong either to the modern genus Tremella, or to the family *Tremellaceæ*.

Museum. A little later came John Bartram who brought to his garden near Philadelphia many plants from the wilds of the southern states, over which he collected extensively. His garden with its quaint old house has appropriately been reserved for a park in which some of the memorials of his labors are still growing. Peter Kalm, whose memory is embalmed in *Kalmia,* the mountain laurel, was sent on a mission from Sweden primarily to investigate the American mulberry in the vain hope that Sweden might have an opportunity to compete with France in the silk industry. Kalm traveled through Pennsylvania, New York and Canada in 1748–51 and took back many plants which served as the originals of some of Linnæus' descriptions. Near the time of our revolution another acute observer lived in New York, Cadwallader Colden by name, and once lieutenant governor of the province. Colden was also one of the correspondents of Linnæus, and a list of his plants was published from Upsala. But the real commencement of our botanical exploration began with two foreign botanists, who came to this country near the close of the eighteenth century, and a third at a little later period. These were Frederick Pursh and André Michaux, and later Thomas Nuttall. Michaux was sent from France to collect living plants for ornamental purposes, and as the result of his exploration took back to his native country more than sixty thousand woody plants. In 1793 he crossed the then wilderness of the Alleghanies into Ohio, going down the river as far as Louisville. Two years later he went farther and pushed up the Wabash to old Vincennes, crossed Illinois to the Mississippi, which he descended as far as the mouth of the Ohio, and then up the Cumberland and across to Charleston; he also went into Florida, then wholly inhabited by Indians. Pursh traveled less widely, but his knowledge of the American flora was more extensive because of his contact with other botanists who supplied him with plants from their own collections. Both Pursh and Michaux published Floras of North America so-called, although the North America of their day was practically limited by the boundaries of the thirteen original colonies, with mere excursions into the wilderness of Indiana on the west, and Florida on the south. Michaux's Flora, edited after his death by Richard, is dated 1803, and Pursh's Flora appeared eleven years later. After them came Thomas Nuttall, who, true to his English instincts, was an extensive traveler. He was in the vicinity of St. Louis in 1810, ascended the Missouri as far as Fort Mandan in 1816, and the Arkansaw as far as Fort Smith in 1818. In 1834–35 he crossed the Rockies to Oregon and California. The results of his travels were published in his 'Genera of North American Plants' and other papers.

It was in the early days of the nineteenth century that botanical activity commenced in New York. Samuel L. Mitchill was one of the first to give instruction in botany, in the intervals when he was not in congress or the senate of the United States. After some struggles David Hosack, his successor as professor in the Medical College, secured the establishment of the Elgin Botanical Gardens in this city by aid from the state of New York. These gardens were located on the square bounded by Madison and Fifth Avenues and Fifty-first and Fifty-second Streets, and although south of the lower end of what is now Central Park, they were too remote from the New York city of a century ago to be much visited by the public, and with the pressure of other duties that came to Hosack they soon went into a decline, and the state finally turned them over to Columbia College, first, to manage as a botanical garden and, finally, as this proved a white elephant, to use for whatever purpose they chose. With strange prescience, the college authorities held to their trust, though at times it was a financial burden, and now this same Elgin Botanical Garden, once so worthless, has become one of the foundations of a university's wealth. A fitting memorial to Hosack may be seen in the two ancient yew trees that once stood in the Elgin Gardens, but now flank the approaches to the library of Columbia University.

But Hosack was more than a mere enthusiast over botanical gardens. He had the gift of enthusing others, and among these was a young lawyer with the large jaw so characteristic of the profession, who afterwards became a teacher and finally went to Williams College. Here he spread the contagion for botanical study, and his students became so enthusiastic over the subject that they volunteered to publish his lectures in a book which became the first of a series of eight editions of the manuals of botany that appeared as precursors of Gray's series of a later period. Amos Eaton owed his success to his large jaw—what has sometimes been called the 'oratorical jaw'—that first impelled him to enter the law. Not alone in botany, but in geology, were his auditors most enthusiastic over his lectures, and one of the state legislatures in joint session invited him to repeat one course before their body. Eaton was perhaps saved from the law for a higher mission through the force of the law itself. For the supposed mismanagement of an estate in Columbia county, he was for a time placed in a debtor's prison in New York city. During his confinement there he amused himself by interesting the bright twelve-year-old son of the prison warden in the study of plants. Here Eaton unconsciously did his greatest work in botany, for the seed, so fortuitously planted, took hold of that twelve-year-old boy and in later years he was known as the Nestor of American botany—John Torrey. But in those early days botany had few emoluments and no endowed chairs. The time for botanical work must be stolen from his recreation hours when not active in his profession, so that while Torrey was first and foremost a botanist from choice, he was a chemist by profession, and managed to work at his beloved plants in the hours not spent in an assaying office or in teaching chemistry to the students of the College of Physicians and Surgeons. His work on the American flora was perhaps the most critical that has ever been done, and when we consider the meager materials known in his period, we are profoundly impressed with his wonderful breadth of mind and the accuracy of his knowledge. So well was Torrey known in 1831 that Asa Gray, just through with his medical studies in central New York, sought out Torrey at New York and commenced his apprenticeship in botany under a master mind. What Gray afterwards became in American botany he owed in large measure to the start given him by John Torrey, a fact Gray himself was not slow to admit, and the friendship of the two men never ceased. Torrey provided Gray a curator's post in the old Lyceum of Natural History in order that he might have the means to carry on his studies; he gave him the encouragement of a father, as well as of an instructor; and he finally associated Gray with himself in the preparation of the first great Flora of North America, a fact that gave Gray at once a name and a standing among botanists abroad. The study on the flora early brought to light the necessity of examining the types of American plants preserved in the collections of Europe, and Torrey, unable to make many visits himself, made it possible for Gray to do this and thus come into personal contact with the older generation of botanical spirits of the old world. The call from Harvard came to Gray in 1843 and closed the combined work of Torrey and Gray on the 'Flora of North America.' Changes in our national history, to which I shall allude later, shifted for a time the studies on the American flora, and before the further publication of the work was possible, Torrey had passed to his last sleep. Gray built up at Cambridge the herbarium and garden that bear his name, and after Torrey's death continued his publication of the 'Synoptical Flora,' but the work was left unfinished when Gray died in 1888.

Contemporary with Torrey in his early days were two botanists we need to mention. One was Stephen Elliott, who published a sketch of the botany of Georgia in 1816–1824 and who may be fairly considered the father of southern botany. Elliott's successor was Dr. A. W. Chapman, who published three editions of the Flora of the Southern States before his death, and Chapman's successor has recently given us an enlarged Flora of the same region. The other contemporary of Dr. Torrey was French in ancestry, a Turk by birth, a Sicilian by adoption, and a vagabond by nature, gifted, versatile, wildly enthusiastic, erratic, much maligned and never understood either by his contemporaries or by his biographers. His name was Rafinesque, which lends itself in rhyme with picturesque and grotesque, and both these adjectives fit him closely as the unique character of American botanical history. So ardent was he in his desire for new descriptions, that when there were no further plants within his reach, he took flight to the clouds and deliberately classified the form of thunder and lightning. He published voluminously and so miscellaneously that some of his papers are still coming to light. Much of his work is worthless, yet there are veins of good interlarded among the bad that it still remains the task of the future to sift and save. In his crazy notions regarding the multiplicity of species, Rafinesque has had no equals, a few weakling imitators, and only one real successor.

While the study of the higher plants was in progress at various places, there were fortunately only a few to study the lower ones. Schweinitz, a Moravian minister, commenced the study of American fungi first in North Carolina and afterwards at Bethlehem, Pennsylvania. He was followed in his study in the south by another clergyman, Moses A. Curtis, who attended to the spiritual needs of his parish on Sunday, and on Monday started out in his old gig for mushrooms. Curtis sent most of his material to Berkeley in England for description, so that the types are at Kew. Later two thirds of all our new fungi were described by Ellis, whose enormous collection is now in the New York Botanical Garden, and by the veteran state botanist of New York, Charles H. Peck, who alone represents the old school of mycologists. The lichens were early studied by Tuckerman, whose collection is at Cambridge, and the mosses by Sullivant and Lesquereux and later by Austin. Harvey early studied our algæ, and he was succeeded by Farlow in New England and by Anderson on the Pacific Coast.

Few students of the present generation are able to understand the conditions that were the rule in the past. A generation ago, instead of well-equipped laboratories of botany, the college boy was fortunate if he could have either botany or zoology as an undergraduate elective at all, and, of course, resident graduate work was practically unknown; if botany was given at all, it was only as a two-hour subject for a short term when the common spring flowers were attainable, for botany then was literally a study of flowers. The whole course of instruction fostered by the text-books of Gray and Wood led only to a dilettante sort of study which in most colleges was taken to fill in a snap elective for an easy time at the close of the senior year. No one thought seriously of botany; it was a sort of fringe on the educational garment, pretty enough, but only adapted to girls to be taken as an accomplishment and classed with decorative daubery and other fancy work. There were only three colleges in the entire country where there was a distinctive professor of botany, and at the best of them there was not enough of the subject in the course to make three points for a full year. Asa Gray was professor at Harvard from 1843 to 1875, and during those thirty-two years, with the large undergraduate body of Harvard to draw on, and with the best facilities at that time that were offered in this country, only a single Harvard man of that period ever became a botanist. In fact, it was not the policy of Asa Gray to develop botanists; he was an ambitious man and he thought to hold the higher flora of North America in his own keeping; if any people attempted to do independent work, they were immediately criticized so roundly that only the bravest ever dared show his hand in print again. But there came a revolt. Asa Gray was, to use his own expression, 'a closet botanist.' After his early days in New York he rarely went afield even in the vicinity of his own home. He knew his plants only as they were found in the *hortus siccus*. He never saw the Mississippi or set foot on a prairie until he was sixty-two, and then took a single hurried trip across the continent with Sir J. D. Hooker. But there were others who studied afield, who knew their plants from their living habits rather than from their fragmentary mummies, and one or two were bold enough to make their own statements in opposition to 'authority' and to stand by them. One of these, a son of New England, but broadened by residence in Illinois, Wisconsin, Colorado and California, raised a standard against the one-man policy that had obtained so long in American botany, and his work was the cause of such mental strain that Gray's nervous tension could not bear it. This revolutionist, stalwart and vigorous, in figure a hybrid between the Farnese Hercules and the Apollo Belvedere, was Edward Lee Greene, and his revolt was the signal for other and younger botanists who soon followed him in the arena. After Gray's death in 1888, the center of study on the North American flora shifted from Cambridge, and new centers sprang up in Washington, at St. Louis, where George Engelmann, one of our German-American botanists, had long been at work, and in California, where Professor Greene then held a university chair. At New York, where botany had been largely dormant since the death of Torrey in 1873, the subject was revived under the leadership of a young man whose modesty forbids my pronouncing a eulogy on him living. To know how well he has developed this center of botanical work one has only to visit the New York Botanical Garden, at once his *magnum opus* and his monument.

The period just preceding the entrance of some of the older of the present generation of botanists to their college studies was a brilliant one in European botany, but all foreign researches were carefully hidden away from us as youngsters. All the splendid work of Hofmeister, of Nägeli, of Von Mohl and of De Bary was unknown to that group of American college students, and the appearance of Sachs's

Botany in 1875 in English was the first intimation to many of us that we had been grossly defrauded in our college course and fed on the gray husks of the subject.

Following the death of Gray, there was also a concerted movement towards a rational system of nomenclature for American plants, following the practise of zoologists in certain points, and finally resulting in more fundamental methods of fixing the types of genera. The first effort leading towards unification was expressed in the so-called 'Rochester Rules' evolved after practically an all-night session of a committee at the Rochester meeting of the American Association for the Advancement of Science in 1892 and passed by a practically unanimous vote the following day. These were modified the following year at the Madison meeting and some unfortunate minor details were introduced that brought about considerable antagonism. This opposition naturally attracted to itself a considerable contingent of morphological and physiological botanists who knew practically nothing about the subject, and never took the trouble to learn, beyond the fact that it produced some change in the use of names with which they had become familiar. Subsequently the necessity for the fixation of generic types[1] became apparent as more serious study of the whole subject advanced, and new features were introduced into what is now known as the 'American Code of Nomenclature.' The mutual concessions at the Vienna Congress of 1905 resulted in removing the most objectionable features of the propositions of both parties in the controversy, and in bringing about practical unanimity on this side of the water. Old beliefs die hard, however, and the region beyond the River Charles appears to be an appropriate place for beliefs to die. The doctrine of fiat creation as opposed to the doctrine of evolution died there a royal death with Louis Agassiz in 1873; and after two vigorous antemortem utterances on the subject by the generations past, the Kew rule, the last vestige of personal as opposed to rational usage in plant nomenclature, has recently stalked off the platform, and is now, so far as America is concerned, a thing of the dead past.

It is interesting to note the effects of political history on a subject so seemingly remote as botany. Before the Franco-Prussian war of 1870, German was almost unknown in our college courses except as an unusual elective. French was then considered the one necessary modern language. The unification of Germany changed all this, and the German language at once took its proper place in our system of

[1] At the present time the zoologists of America are struggling over this problem of generic types, and ideas of what the principle really means are actually penetrating the German mind, slower in grasping the real significance of this problem. When this principle once takes root among the botanical workers on the continent, not even the 'railroading' methods of the Vienna Congress will be able to stem the tide of real progress.

education. The works of German scholars, previously buried to all but the select few, became more widely known, and many of them were translated into English and thus brought within the reach of all students. The German language has become a *sine qua non* of the botanist in whatever field of investigation he enters, and a prominent cause of the backwardness and decline of botany in England, during the generation just past, is largely attributable to the fact that until very recently few of their botanists have been able to read the German language.

A few influences were prominent in bringing about better instruction in botany. Foremost among these was the introduction of the laboratory method in biology, when an impetus was given by Huxley and his students to zoology which reacted on the cognate science of plant life. While the laboratory method has often been carried to an extreme, especially in the exclusion of field work as a means of culture, it has, nevertheless, resulted in developing in America a laboratory technique that is the envy of even the astute Germans. It is a well-known fact that with all the prowess of the German, it took an American botanist to introduce into the German laboratory the method of the microtome with its serial section.

Another factor was the more general introduction of better text-books and works of reference, a condition difficult for the younger generation to realize. I have mentioned the first translation of Sachs' Botany in 1875. This was soon followed by the later work of De Bary and others. But even Sachs was too advanced for the average student of the early days. Perhaps no single book did more to serve as a logical introduction to the more advanced literature of the subject and to give to younger students their first broad outlook in botany, than that issued in 1878 by one of the most successful teachers of botany in America—as well as one of the most genial of men—Professor Charles E. Bessey.

Thirty years ago there were, as we have said, only three professors of botany in all this country. Now the species has become so common that one is no longer a novelty; in the colleges of America there are now nearly one hundred botanical laboratories manned with from one to ten botanists each. Thirty years ago there was a single botanist at Washington, regularly employed by the government to report on some new weed that appeared, and to assist the congressmen in their annual gifts of seeds to their constituents; now we have at least one hundred and fifty in the well-equipped laboratories of the Bureaus of Plant Industry and Forestry at Washington alone, and nearly as many more at the fifty agricultural experiment stations in every state of the union, where all phases of botany, physiological, pathological and economic, are being arduously pursued. Thirty years ago botany was a subject thought to be fit only for girls, but now it ceases to cause a smile when full-grown men take to it seriously, though some of our antiquated coworkers in other university lines still wonder how it is possible to teach the subject except when the spring sunshine favors the growth of the early flowers!

Space forbids us more than the mere mention of some of the varied divisions of the subject that under the hands of modern masters have grown to be broad special sciences of themselves, though still branches of botany. We need only mention the growth of paleobotany from the days of Newberry to its modern phases, as carried on by Jeffrey and Hollick; of cytology, under Harper and Davis; of embryology, under Coulter, Johnson and Campbell; of ecology, under Cowles and Clements; of plant breeding, under Bailey and Webber; of mycology under Arthur, Thaxter and Burt; of economic botany, under Fernow and Rusby; and there are still other fields into which our science has broadened.

It is interesting to note how the study of the American flora has gone hand in hand with the political development of the country. When Torrey and Gray published their first great flora of North America in 1838–1843, the territory of the United States, which was all it attempted to cover, was very largely east of the Mississippi. Buffaloes and Indians held the great west from Arkansas to the Saskatchewan. Texas was just struggling for freedom from Mexico, as Mexico herself had recently struggled to secure her own liberation from Spain. Colorado, Utah, Nevada, Arizona and all California were quiet Mexican provinces undisturbed by the searcher either for ore or for plants, as peaceful as when the first missionaries of the cross opened up their missions among them, two centuries before. Soon politics entered and commerce, its ally, followed in its wake. The annexation of Texas in 1845 was followed by the Mexican war, through which the region from Texas to Oregon came over as the first great expansion of American territory since the Louisiana purchase. Then on the heels of annexation came the discovery of gold in California, and the wild rush towards that Eldorádo changed that territory in a twelvemonths from a quiet colony to a great bustling state clamoring for its full rights, and seeking to be joined to her sister states, not only by the bonds of fraternity, but by the practical iron bands of the Pacific railroad that made commerce possible with them. In the wake of all this war, annexation, settlement, exploration for railroads, came the botanical explorer, and the floral wealth of the great West was poured into Eastern collections with Torrey at New York, and Gray at Cambridge, and to a much less degree with Engelmann at St. Louis.

A word of mention is due to some of the early and later botanical explorers to whom we owe so much in those days when it was less possible than now for botanists themselves to extend their studies afield and learn the flora in its native heath and study it in its associations and in its relations to soil, temperature, moisture and climate. Among these early field botanists was Charles Wright, who explored Texas, New Mexico and Nicaragua, and all through the period of our civil war and later spent his years in Cuba and made known the flora that its native and introduced Spanish inhabitants had ever been expecting to study themselves in their glorious mañana, the never-appearing period when this race does its leading work. Wright with his boyish spirit was Dr. Gray's 'Carlo,' a name given not only in sport, but seriously embalmed among plant names in Gray's genus *Carlowrightia*. Then there were Fendler and Lindheimer, both German-Americans, who collected in Texas and New Mexico, and Fendler later in Panama, Venezuela, and last of all in Trinidad, where he died in 1883. There was also the old Pathfinder, Fremont, who made collections in California and over the Oregon trail; and Parry, quiet, open-hearted, the type of the sincere botany man, who ranged over the great west from his home in Iowa to the Mexican boundary and the golden gate of the Pacific. Later, Lemmon explored the high Sierras and Arizona, and Brandegee, led on from his surveys of the Denver and Rio Grande, left enginering for botany and explored from the Great Basin to the lowest confines of Baja California. Both of these were followed by the veteran collector, Pringle, who finding Arizona and California too small for his ambitions, traveled year after year throughout Mexico from Chihuahua to Tehuantepec. Time forbids the mention of the many others, even by name, who, in their untiring zeal for botanical exploration, not unlike those mentioned by the sacred writer, "subdued kingdoms . . . quenched the violence of fire, escaped the edge of the sword . . . out of weakness were made strong . . . wandered about in sheep-skins and goat skins . . . of whom the world was not worthy." To these botanical explorers we owe a debt of profound gratitude.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

BY FRED DELAND
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IX. TELEPHONE LINE CONSTRUCTION.

IN 1876 the wires used for telegraph circuits were usually of iron or steel, because the tensile strength permitted of long spans and comparatively long sag. At that period hard-drawn copper line wire was unknown, and it is problematical whether the volume of traffic passing over the average telegraph wire at that time, outside of the main trunk lines, would have justified the heavy initial investment required to string copper circuits. Thus it came about that iron and steel wires were naturally adopted for telephone lines.

About that time George B. Prescott wrote that

> a very short experience with copper line wires both in this country and in Europe, proved that this metal was altogether unsuitable for the purpose, its sole recommendation consisting in its superior conductivity, and it was, therefore, soon replaced by iron wire of large diameter.

But T. B. Doolittle proved how fallacious that theory was, by producing a hard drawn copper wire in 1877, that, as stated in Chapter V., proved of inestimable value to telephone interests the world over.

This failure on the part of soft drawn copper wire to satisfactorily serve as line wire was due to the unpleasant habit it had of not staying where it was placed; it lacked the physical stamina to support itself, and would break with its own weight. This fact was well known to telephone men. Yet few perceived the merit in Mr. Doolittle's improvement, or took kindly to it until forced to do so by later conditions. In 1880, three years after Mr. Doolittle's experimental hard drawn copper line had been strung in Ansonia, Connecticut, a telephone line gang started to string a toll circuit between Hartford and New Britain, but completed less than five miles. This circuit consisted of one No. 18 soft drawn copper 'office' wire, having a double braided cotton covering saturated with paraffine; but by reason of the long spans between the poles the sag was sufficient to cause the small soft wire to break with its own weight. Thus, after spending several days in rejoining broken ends, the circuit was abandoned, and iron wire strung in its place.

In cities and wherever the iron circuits were subjected to the destructive effects of atmospheric action, especially where much bituminous coal was used, oxidization shortened the life of the circuits in the pioneer telephone days, just as now happens thirty years later. The prevailing belief among the early telephone men was that iron wire would have an average life of from fifteen to twenty years. But it only required a brief experience to show that many iron circuits on city pole lines, even of extra best (E. B. B.), had an average life of less than four years, and that rapid rusting rendered some circuits worthless within three years.

For pole lines, chestnut was the principal wood used in 1876, though there were also many white and some red cedar poles used, and here and there a few locust and oak poles were occasionally utilized. The number of poles then placed to the mile varied according to the climate and the breadth of view of the owner. Ordinarily they ranged from fifteen to forty, the average in the northern states being from twenty-five to thirty, according to the downward range in temperature. As a rule, poles 25 feet in length answered every purpose, for there were no other lines to interfere, while 4-inch or 5-inch tops offered sufficient support to carry the few wires required in 1878–80.

Now-a-days the approved practise in building telephone trunk lines is to require selected heavy chestnut or cedar poles, not less than eight inches in diameter at the top, and with a corresponding heavy butt, and in length ranging from thirty to fifty feet, depending on the contour of the country and the number of circuits to be carried. From forty-four to fifty of these poles are placed per mile, while the depth that they are set in the ground ranges from five feet to nine feet, depending on the length of the pole and the character of the soil or rock.

It may be recalled that in the first circular issued by 'the proprietors of the telephone,' dated Cambridge, Mass., May, 1877, Gardiner G. Hubbard stated that

telegraph lines will be constructed by the proprietors, if desired. The price will vary from $100 to $150 a mile; any good mechanic can construct a line; No. 9 wire costs 8½ cents a pound, 320 pounds to the mile; 34 insulators at 25 cents each; the price of poles and setting varies in every locality; stringing wire $5 per mile; sundries, $10 per mile.

At the first glance the amount of material shown in that estimate may appear somewhat inadequate, judged by modern methods of standard pole line construction, calling for forty-four poles to the mile. Yet a moment's study will show that the proposed line was substantially planned, was far stronger and would probably possess far better talking qualities than some present day private lines. In an elaborate catalogue issued by a manufacturing telephone company in 1906, twenty-nine years after Mr. Hubbard's circular was issued, the following estimate appears:

To give something of an idea of the expense of building one mile of line, grounded circuit (1 wire), we submit the following items. We do not estimate the cost of poles, which can usually be obtained in your own locality, using twenty-five 25-foot, 5-inch top poles to the mile:

165 lbs. No. 12 galvanized B. B. iron wire	$6.80	
25 Oak brackets	.30	
25 Pony glass insulators	.37	
25 60-penny and 25 40-penny nails	.25	$7.72

On February 1, 1878, the Bell Telephone Company of Boston, the second of the parent associations, issued circular No. 3, reading in part:

When the (District telegraph) company does not desire (to introduce) the Bell telephone, a District telephone company should be organized, and *metallic circuits* constructed, running from the central office to various parts of the city. . . . The stock to be issued for the cost, in any case, should not exceed one hundred dollars a mile of wire, including all fixtures.

Evidently good telephone line construction was considered too expensive to justify introducing the telephone in many places, for one year later, the parent company issued a circular bearing the caption 'Telephonic Exchange System,' and detailing a combination of the advantages of the different exchanges in operation. Therein it barely touched upon the construction of line circuits, but called attention to the now well-known fact 'that repairs on line' are part of the current expense, an item that companies organized during late years have been prone to charge to construction and capitalize. But later, in 1879, the third parent company issued a pamphlet of instructions from which the following item is taken:

The line wire generally used is the No. 12 galvanized iron, and a line built of this wire, if securely put up, will last for years without repairs. Where a cheaper line is desired, No. 14 or 16 iron wire, or a small copper or brass wire may be used, but smaller wires than No. 12 are very liable to be broken by storms and high winds, and it is always cheaper in the end to use wire at least as large as No. 12. In towns or cities the wire can be run over house-tops, using small glass pony insulators and wooden brackets. About thirty of these insulators and brackets are needed for a line one mile long. They can be nailed to the side of a chimney, to the ridge-pole or side of a house, or to a pole. When there are no houses to support the wire, poles must be used. These are generally about twenty feet long, four inches in diameter at the top, and are set four feet into the ground. Care should be taken to keep the wire from touching anything except the glass insulators. The line wire should terminate on the outside of the stations, and the connections be made to the instruments by No. 16 or No. 18 insulated office wire, which is wound tightly around the iron wire and soldered.

Possibly construction of so cheap a character was too costly to meet the approval of many early operating companies, so to meet this uneconomical demand for cheapness regardless of permanency, a new set of instructions was issued by the parent company, which read, in part, as follows:

Lines up to six miles in length can be built of No. 14 galvanized iron B. B. wire. Lines over six miles and not over 25 miles should be built either of No. 11 or No. 12 galvanized iron B. B. wire. Lines over 25 miles in length should be built of No. 11 galvanized iron B. B. wire. We recommend the use of porcelain insulators, they being the best as well as the cheapest. Trees, house-tops and poles can be used in the construction of a line. When fastening a line to a tree, let your wire slack enough to swing to and fro with the tree, otherwise your line will be broken during a windstorm. Tree limbs or branches touching the wire have no bad effect on the telephone, but should be avoided if easily possible. A pole should be set no less than three feet in the earth and eighteen to thirty to the mile. Always try and keep your poles in a straight line.

The flimsy character of such cheap and improper telephone line construction is readily apparent, and we now wonder why the local owners should have been led into such expensive errors. Yet the waste of thousands of dollars in construction of the cheapest character is readily explainable on the ground that few had any faith in the future of telephone service; it was an experiment that might require years to demonstrate its value; thus capitalists refused to countenance the large initial expenditures required in constructing pole lines possessing qualities of permanency and stability.

Again, this kind of line construction was just as good, and in some cases far superior, to that adopted by several telegraph companies during the decade preceding the invention of the telephone. This is shown in the report rendered in 1868, by C. F. Varley, a well-known electrician of the English telegraph companies, who made a thorough inspection of telegraph lines in the United States. Mr. Reid states that this report,

which was very minute and exhaustive, was a startling revelation of the condition of the American wires. The obstruction by imperfect joints, by relay magnets of all grades of resistance, by impure wire, by contact, by defective and neglected insulation was more or less universal. Many of the original wires were small, naked, full of joints made in all conceivable ways, into which the detained moisture ate a path of rust and ruin.

Eight years later, that is, in 1875, David Brooks wrote:

The rates of telegraphing in this country have always been high, yet but few of the stockholders or those who furnish the money to construct the lines have ever received any return for their investments. In most cases the Morse patent was sold to individuals who organized companies, received subscriptions to stock, and constructed the lines, deriving personally large profits thereby. Usually, about three times the amount of money necessary to build the lines was subscribed by the stockholders, and an equal amount of stock was issued for the patent; so that those organizing the companies not only derived large profits from the construction of the lines, but also held the controlling interest in the stock. By this mode of procedure a few individual speculators have each succeeded in realizing far greater profits from the Morse patent than were ever realized by its inventor.

In 1880, the parent Bell company issued further instructions that it believed would be of service to the operating telephone companies, stating:

It is advisable, where there are numerous wires, to have a cupola erected on the roof of the building where the central office is located, and through it the line wires are conducted to the operating-room. . . . The cupola is about six feet square, eight feet high above the eaves, and about eighteen inches more at the ridge-pole. . . . It is better to have the cupola open into the operating room when the room is in the top story of a building, and cleats are fastened round the inside, bored with a number of holes, corresponding to the number of wires required. . . . The wires, after entering are led to the lightning arrester, then run through the holes in the cleats, which run round the base of the cupola, to the ceiling of the operating room, along which they are carried, on other hard wood cleats, to the switchboard. . . . Where the main lines are not sufficiently numerous to render a cupola necessary, they may be brought through a window in the central office. . . . (Fig. 37.) The line wires are strung on (pony) glass insulators, which are fitted to wooden pins, driven into crossarms. These crossarms are supported on poles or house-top fixtures, which should be run in trunk-routes through the city or town, branch lines being run to any desired point. It is advantageous to use poles wherever practicable, for the following reasons: Pole lines are not liable to interference from householders, being entirely out of their control; they are much more accessible at all times, and when they are out of order at all the trouble is more easily located and removed; the cost is generally about the same, where the number of wires to be carried does not exceed forty or fifty. Poles should be not less than twenty-five feet long, with a diameter of six inches at the top; and should be set five feet in the ground. Before being set up, poles should be carefully stripped of the bark, and, when used in cities, should be painted. It is the usual practise to place *all* the crossarms on one side of the pole, fastening them with bolts and nuts. It is sometimes, however, absolutely necessary to run house-top lines. Trunk routes should then be selected, and along these routes structures must be erected at an average distance of about three hundred feet apart. Fig. 38 represents a roof fixture, with four cross-bars, each bar having glass insulators on its upper side, and 'hook' insulators on its under side, thus doubling its capacity for carrying wires. Hooks being expensive, porcelain knobs may be substituted for them as an economical measure. (A foot note reads: It is much better to avoid adding hook or other fixtures to the lower edge of cross-bars. It is apt to bring the wires too near together, and cause trouble from 'induction.' It should be done only when new fixtures cannot possibly be erected.) A correct idea of a 'double wall fixture' may be obtained from Fig. 39. It is in many cases desirable to use this style of fixture in preference to a roof fixture, as removing all danger of causing leaks in roofs; or in cases where flat roofs are not attainable, or where the point of support is necessarily a high party wall or the side wall of a building. . . . Bad construction, necessitating frequent clambering over roofs, while it may do no real harm to the premises, annoys owners and tenants, whose condemnations and complaints soon reach the ears of others, and this is apt to put stumbling-blocks in the way of securing permission for entering upon new

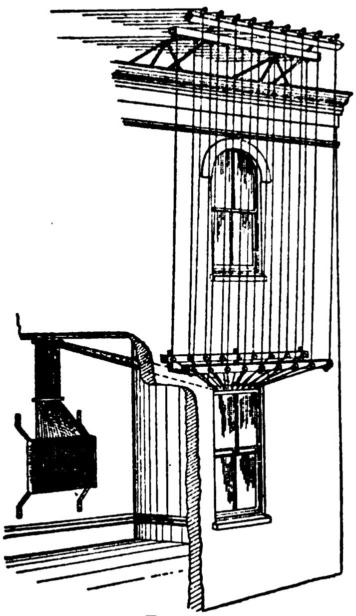

FIG. 37.

premises. Besides these reasons, it can readily be seen that work is the cheapest in the end that does not need extensive or frequent repairs.

Only the old-timers can appreciate what endless trouble was caused by careless linemen climbing on the roofs of residences and attaching wires, without consulting owner or occupant. For a costly experience soon showed that many tin or asphaltum roofs that were in apparent good order, before trespassed upon, were punctured or broken by the negligent dropping of a hatchet or other tool, or by heavily walking over weak parts. Then shingles and boards were split by big nails improperly driven to fasten insulator or bracket, bricks were chipped

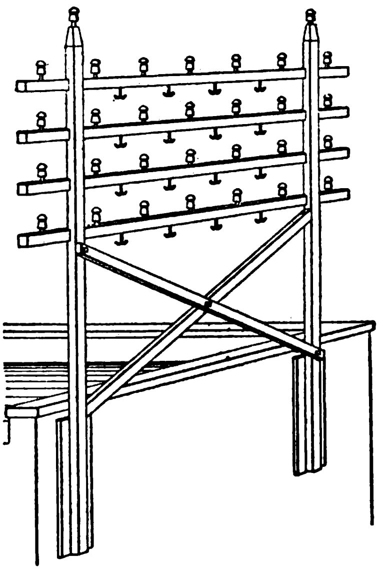

FIG. 38.

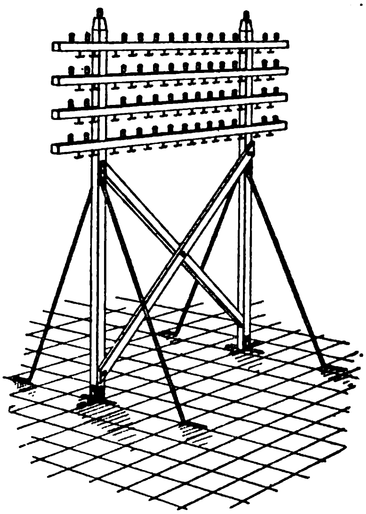

FIG. 39.

and paint knocked off. To the owner, the aggravating part was that this damage was not likely to be discovered until the next heavy rain, and then so long a time elapsed between the trespass and the injury that it was difficult to say just who was to blame.

As the number of subscriber lines increased in the early days, the necessity of longer and heavier poles became apparent. Then the use of higher poles resulted in the attaching of more cross-arms to the main line, until finally the principal object of some companies appeared to be to determine how many open wires a pole line could safely carry. For there are records of pole lines in many cities carrying as high as a hundred open wires, while in a few cities from 150 to 200 wires were carried. What is said to have been the largest and highest telephone pole line in the world was erected on West Street in New York City. The poles forming this line were of Norway pine ranging from sixty to ninety feet in height and carrying from twenty-five to thirty crossarms each.

THE VALUE OF SCIENCE

By M. H. POINCARÉ

MEMBER OF THE INSTITUTE OF FRANCE

4. '*Nominalism*' *and* '*the Universal Invariant*'

If from facts we pass to laws, it is clear that the part of the free activity of the scientist will become much greater. But did not M. LeRoy make it still too great? This is what we are about to examine.

Recall first the examples he has given. When I say: Phosphorus melts at 44°, I think I am enunciating a law; in reality it is just the definition of phosphorus; if one should discover a body which, possessing otherwise all the properties of phosphorus, did not melt at 44°, we should give it another name, that is all, and the law would remain true.

Just so when I say: Heavy bodies falling freely pass over spaces proportional to the squares of the times, I only give the definition of free fall. Whenever the condition shall not be fulfilled, I shall say that the fall is not free, so that the law will never be wrong.

It is clear that if laws were reduced to that, they could not serve in prediction; then they would be good for nothing, either as means of knowledge, or as principle of action.

When I say: Phosphorus melts at 44°, I mean by that: All bodies possessing such or such a property (to wit, all the properties of phosphorus, save fusing-point) fuse at 44°. So understood, my proposition is indeed a law, and this law may be useful to me, because if I meet a body possessing these properties I shall be able to predict that it will fuse at 44°.

Doubtless the law may be found to be false. Then we shall read in the treatises on chemistry: "There are two bodies which chemists long confounded under the name of phosphorus; these two bodies differ only by their points of fusion." That would evidently not be the first time for chemists to attain to the separation of two bodies they were at first not able to distinguish; such, for example, are neodymium and praseodymium, long confounded under the name of didymium.

I do not think the chemists much fear that a like mischance will ever happen to phosphorus. And if, to suppose the impossible, it should happen, the two bodies would probably not have *identically* the same density, *identically* the same specific heat, etc., so that, after having determined with care the density, for instance, one could still foresee the fusion point.

It is, moreover, unimportant; it suffices to remark that there is a law, and that this law, true or false, does not reduce to a tautology.

Will it be said that if we do not know on the earth a body which does not fuse at 44° while having all the other properties of phosphorus, we can not know whether it does not exist on other planets? Doubtless that may be maintained, and it would then be inferred that the law in question, which may serve as a rule of action to us who inhabit the earth, has yet no general value from the point of view of knowledge, and owes its interest only to the chance which has placed us on this globe. This is possible, but, if it were so, the law would be valueless, not because it reduced to a convention, but because it would be false.

The same is true in what concerns the fall of bodies. It would do me no good to have given the name of free fall to falls which happen in conformity with Galileo's law, if I did not know that elsewhere, in such circumstances, the fall will be *probably* free or *approximately* free. That then is a law which may be true or false, but which does not reduce to a convention.

Suppose the astronomers discover that the stars do not exactly obey Newton's law. They will have the choice between two attitudes; they may say that gravitation does not vary exactly as the inverse of the square of the distance, or else they may say that gravitation is not the only force which acts on the stars and that there is in addition a different sort of force.

In the second case, Newton's law will be considered as the definition of gravitation. This will be the nominalist attitude. The choice between the two attitudes is free, and is made from considerations of convenience, though these considerations are most often so strong that there remains practically little of this freedom.

We can break up this proposition: (1) The stars obey Newton's law, into two others; (2) gravitation obeys Newton's law; (3) gravitation is the only force acting on the stars. In this case proposition (2) is no longer anything but a definition and is beyond the test of experiment; but then it will be on proposition (3) that this check can be exercised. This is indeed necessary, since the resulting proposition (1) predicts verifiable facts in the rough.

It is thanks to these artifices that by an unconscious nominalism the scientists have elevated above the laws what they call principles. When a law has received a sufficient confirmation from experiment, we may adopt two attitudes: either we may leave this law in the fray; it will then remain subjected to an incessant revision, which without any doubt will end by demonstrating that it is only approximative. Or else we may elevate it into a *principle* by adopting conventions such that the proposition may be certainly true. For that the procedure is always the same. The primitive law enunciated a relation between two facts in the rough, A and B; between these two crude facts is introduced an abstract intermediary C, more or less fictitious (such was in the preceding example the impalpable entity, gravitation). And then we have a relation between A and C that we may suppose rigorous and which is the *principle;* and another between C and B which remains a *law* subject to revision.

The principle, henceforth crystallized, so to speak, is no longer subject to the test of experiment. It is not true or false, it is convenient.

Great advantages have often been found in proceeding in that way, but it is clear that if *all* the laws had been transformed into principles *nothing* would be left of science. Every law may be broken up into a principle and a law, but thereby it is very clear that, however far this partition be pushed, there will always remain laws.

Nominalism has therefore limits, and this is what one might fail to recognize if one took to the very letter M. LeRoy's assertions.

A rapid review of the sciences will make us comprehend better what are these limits. The nominalist attitude is justified only when it is convenient; when is it so?

Experiment teaches us relations between bodies; this is the fact in the rough; these relations are extremely complicated. Instead of envisaging directly the relation of the body A and the body B, we introduce between them an intermediary, which is space, and we envisage three distinct relations: that of the body A with the figure A' of space, that of the body B with the figure B' of space, that of the two figures A' and B' to each other. Why is this detour advantageous? Because the relation of A and B was complicated, but differed little from that of A' and B', which is simple; so that this complicated relation may be replaced by the simple relation between A' and B' and by two other relations which tell us that the differences between A and A', on the one hand, between B and B', on the other hand, are *very small.* For example, if A and B are two natural solid bodies which are displaced with slight deformation, we envisage two movable *rigid* figures A' and B'. The laws of the relative displacements of these figures A' and B' will be very simple; they will be those of geometry. And we shall afterwards add that the body A, which always differs very little from A', dilates from the effect of heat and bends from the effect of elasticity. These dilatations and flexions, just because they are very small, will be for our mind relatively easy to study. Just imagine to what complexities of language it would have been necessary to be resigned if we had wished to comprehend in the same enunciation the displacement of the solid, its dilatation and its flexure?

The relation between A and B was a rough law, and was broken up;

we now have two laws which express the relations of A and A', of B and B', and a principle which expresses that of A' with B'. It is the aggregate of these principles that is called geometry.

Two other remarks. We have a relation between two bodies A and B, which we have replaced by a relation between two figures A' and B'; but this same relation between the same two figures A' and B' could just as well have replaced advantageously a relation between two other bodies A'' and B'', entirely different from A and B. And that in many ways. If the principles and geometry had not been invented, after having studied the relation of A and B, it would be necessary to begin again *ab ovo* the study of the relation of A'' and B'' That is why geometry is so precious. A geometrical relation can advantageously replace a relation which, considered in the rough state, should be regarded as mechanical, it can replace another which should be regarded as optical, etc.

Yet let no one say: But that proves geometry an experimental science; in separating its principles from laws whence they have been drawn, you artificially separate it itself from the sciences which have given birth to it. The other sciences have likewise principles, but that does not preclude our having to call them experimental.

It must be recognized that it would have been difficult not to make this separation that is pretended to be artificial. We know the rôle that the kinematics of solid bodies has played in the genesis of geometry; should it then be said that geometry is only a branch of experimental kinematics? But the laws of the rectilinear propagation of light have also contributed to the formation of its principles. Must geometry be regarded both as a branch of kinematics and as a branch of optics? I recall besides that our Euclidean space which is the proper object of geometry has been chosen, for reasons of convenience, from among a certain number of types which preexist in our mind and which are called groups.

If we pass to mechanics, we still see great principles whose origin is analogous, and, as their 'radius of action,' so to speak, is smaller, there is no longer reason to separate them from mechanics proper and to regard this science as deductive.

In physics, finally, the rôle of the principles is still more diminished. And in fact they are only introduced when it is of advantage. Now they are advantageous precisely because they are few, since each of them very nearly replaces a great number of laws. Therefore it is not of interest to multiply them. Besides an outcome is necessary, and for that it is needful to end by leaving abstraction to take hold of reality.

Such are the limits of nominalism, and they are narrow.

M. LeRoy has insisted, however, and he has put the question under another form.

Since the enunciation of our laws may vary with the conventions that we adopt, since these conventions may modify even the natural relations of these laws, is there in the manifold of these laws something independent of these conventions and which may, so to speak, play the rôle of *universal invariant?* For instance, the fiction has been introduced of beings who, having been educated in a world different from ours, would have been led to create a non-Euclidean geometry. If these beings were afterward suddenly transported into our world, they would observe the same laws as we, but they would enunciate them in an entirely different way. In truth there would still be something in common between the two enunciations, but this is because these beings do not yet differ enough from us. Beings still more strange may be imagined, and the part common to the two systems of enunciations will shrink more and more. Will it thus shrink in convergence toward zero, or will there remain an irreducible residue which will then be the universal invariant sought?

The question calls for precise statement. Is it desired that this common part of the enunciations be expressible in words? It is clear then that there are not words common to all languages, and we can not pretend to construct I know not what universal invariant which should be understood both by us and by the fictitious non-Euclidean geometers of whom I have just spoken; no more than we can construct a phrase which can be understood both by Germans who do not understand French and by French who do not understand German. But we have fixed rules which permit us to translate the French enunciations into German, and inversely. It is for that that grammars and dictionaries have been made. There are also fixed rules for translating the Euclidean language into the non-Euclidean language, or, if there are not, they could be made.

And even if there were neither interpreter nor dictionary, if the Germans and the French, after having lived centuries in separate worlds, found themselves all at once in contact, do you think there would be nothing in common between the science of the German books and that of the French books? The French and the Germans would certainly end by understanding each other, as the American Indians ended by understanding the language of their conquerors after the arrival of the Spanish.

But, it will be said, doubtless the French would be capable of understanding the Germans even without having learned German, but this is because there remains between the French and the Germans something in common, since both are men. We should still attain to an understanding with our hypothetical non-Euclideans, though they be not men, because they would still retain something human. But in any case a minimum of humanity is necessary.

This is possible, but I shall observe first that this little humanness which would remain in the non-Euclideans would suffice not only to make possible the translation of *a little* of their language, but to make possible the translation of *all* their language.

Now, that there must be a minimum is what I concede; suppose there exists I know not what fluid which penetrates between the molecules of our matter, without having any action on it and without being subject to any action coming from it. Suppose beings sensible to the influence of this fluid and insensible to that of our matter. It is clear that the science of these beings would differ absolutely from ours and that it would be idle to seek an 'invariant' common to these two sciences. Or again, if these beings rejected our logic and did not admit, for instance, the principle of contradiction.

But truly I think it without interest to examine such hypotheses.

And then, if we do not push whimsicality so far, if we introduce only fictitious beings having senses analogous to ours and sensible to the same impressions, and moreover admitting the principles of our logic, we shall then be able to conclude that their language, however different from ours it may be, would always be capable of translation. Now the possibility of translation implies the existence of an invariant. To translate is precisely to disengage this invariant. Thus, to decipher a cryptogram is to seek what in this document remains invariant, when the letters are permuted.

What now is the nature of this invariant it is easy to understand, and a word will suffice us. The invariant laws are the relations between the crude facts, while the relations between the 'scientific facts' remain always dependent on certain conventions.

(*To be concluded*)

THE ACQUISITION OF LANGUAGE AND ITS RELATION TO THOUGHT[1]

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FOR a few years the great Samuel Johnson kept an academy for young gentlemen. It was not a success, despite the fact that he had the two Garricks as pupils. Johnson was not fitted for the work. Yet, little as Johnson succeeded as a teacher, he was himself a monument of mental training—his memory colossal, his style the classic for the English language, his wit so keen as to make Boswell's six volumes of biography perennially good reading. If he could not teach others, he had succeeded in teaching himself. We are bound to give due weight to his views on his own education. To what did he attribute its success?

When Langton asked him how he had acquired so accurate a knowledge of Greek and Latin, 'the Doctor' replied: "My master whipped me very well; without that, sir, I should have done nothing." "I would rather have the rod a general terror to all to make them learn than tell a child: 'If you do thus or thus, you will be esteemed above your brothers and sisters.' The rod produces an effect which terminates in itself, whereas by exciting emulation and comparisons of superiority you lay the foundations of lasting mischief." The rod was Johnson's instrument of education. What were his materials? What subject did he consider as the most suitable vehicles of education? A single illustration will reveal his whole mind.

Writing to a young friend who had asked his advice as to the best subjects for him to study before entering the university—he must have been a lad of fifteen or sixteen years old—Johnson says: "I know not well what books to direct you to *because you have not informed me what study you will apply yourself to.* I think it will be best for you to apply yourself wholly to the languages until you go to the university. The Greek authors I recommend you to read are these: Cebes, Ælian, Lucian, Xenophon, Homer, Theocritus, Euripides. Thus you will be tolerably skilled in the dialects, beginning with Attic, to which the rest must be referred." Then follows a still more appalling list of Latin writers. Johnson "does not know the study to which his young friend intends to apply himself." But, whatever his destined

[1] Presidential address to the Teachers' Guild of Great Britain and Ireland, delivered at University College, London, May 22, 1906.

profession—law, medicine, the Church or mercantile life—he has no doubt as to the course of preliminary training. So far as one can judge, his system was uniform and invariable for all kinds of mind, for all walks in life—Greek and Latin driven in with the rod. "Boys, be pure in heart," said Keate, the famous Eton Head Master; "I'll flog you if you are not." "Boys acquire a tolerable knowledge of the dialects," said Johnson; "take in your knowledge through the eye and ear if you can; but, if you fail to do this, I will undertake to insert it through some other part of your personality." His recommendations to his young friend are pellucidly ingenuous. He is to apply himself to the languages and even to the dialects. There is no pretence in this. No false issue is raised. Johnson does not for a moment suggest that his young friend has anything to gain from the subject-matter of Ælian's or Xenophon's or Theocritus's works. The scholars of the Renaissance studied Latin and Greek for the sake of getting at the writer's thought. They found that Greeks and Romans knew so much more than they did, and argued so keenly about what they knew, that it seemed futile to medieval students to obtain knowledge at first hand. Plato and Aristotle could teach them more than they could ever find out for themselves. By the beginning of the eighteenth century the wisdom of Plato and Aristotle had been absorbed into modern thought. The reason for studying Greek and Latin had gone. Yet the languages had a firmer hold upon the schools and universities than they had ever had before. Their study molded the mind of Johnson, and has molded the minds of the greatest of our statesmen, lawyers, philosophers ever since.

Why should *the* languages produce such admirable results? Johnson does not recognize French, German, Italian as coming within the category of languages when thinking of education. They may be useful for business, or even for lighter employment; but they do not train the mind. Why should languages which have lost their purpose as means of communication possess virtues which living languages can not acquire? In a limited sense their uselessness is their chief merit. *Amo, amas, amat.* The boy who learns the meaning of *j'aime* or *ich liebe* might have an eye upon the possible application of this knowledge; but *amo, amas*—he would not be understood even by a modern Roman maiden!

If attention is to be concentrated wholly upon language as a means, there must be no risk of distraction due to the contemplation of its possible end. "Waiter, *'mrangs!*" called the little boy in *Punch*. "Oh, Freddy, that isn't the way to pronounce *m-e-r-i-n-g-u-e-s!*"—"It's the way to get 'em!" When we are working at a living language thought passes on ahead to the end to be gained. It is only when a dead language is being studied that attention can be wholly devoted to its form. A modern language is studied with a view to 'getting there,' as an American would phrase it. Only a dead language can be looked at as a vehicle, with due regard to its carrying capacity and its power of going, but with no thought of either its particular cargo or its destination.

For something like ten years a public-school boy is daily exercised in the analysis of sentences in Latin and Greek and in the construction of sentences in the same style. He is working at languages which are elaborately inflected, and articulated according to almost innumerable rules. It is a mental exercise which is not supplied in quite the same form by means of the analysis and synthesis of English. German, French, Italian are troublesome to learn; but it is not the rules, but their infraction, the perversities of the language, which tax the memory. Greek and Latin are far from being guiltless of 'exceptions'; yet their architecture, although more elaborate, adheres more closely to a type-form than does that of any modern European language. Each year the schoolboy becomes more expert in expressing, in English, the meaning of his classic author. He recognizes the force, in the expression of thought, of case and mood and voice. He notes the effect upon sense of the position and juxtaposition of words, and of the substitution of one word for another which at first glance appears to mean the same thing. And, since, psychologically, it is impossible to distinguish between thought and the expression of thought, his power of thinking develops *pari passu* with his capacity of giving form to his thoughts. He acquires a feeling for style—the compromise between yielding to the gratification of the ear and the businesslike jerking out of words—the response to the music of language without forgetfulness of its meaning—style, a quality which all the adjectives in the dictionary leave undefined. A man who has had a classical education has a craftsman's feeling for literature: he regards it as an artist regards a picture. The only questions which a layman asks are: 'Is it beautiful?' and 'What does it mean?' The artist can never quite dissociate his criticism of the result from his consideration of the means by which it was attained.

The mind-making property of the study of the classics has been established beyond all doubt by innumerable experiments made upon juvenile minds of all types. It does not appear to me that, in the face of this mass of accumulated evidence, it can be regarded as a question open to dispute. It is not equally clear that the study of the classics stands alone in its potentiality of generating the power of thinking. Owing to the monopoly of the classics in the best class of schools, for the past three hundred years, other subjects have had no chance of showing what they can do.

The teaching of the classics has, *pace* the reformers who are calling out for improved methods, been brought to perfection by generations of school masters, working under the guidance of daily experience;

not aiming at the application of theories which might or might not hold true. The teaching of 'modern' subjects has not as yet settled into custom similarly guided by the observation of results. The essential difference between the classical and the modern system is the difference between training and teaching. A classical education is practically a training pure and simple: a modern education is a combination of training and teaching with mainly a teaching aim. In the pressure and struggle of life it is undoubtedly to the advantage of young people that they should, when they leave school, not only have the strength and agility which will enable them to use any weapon, but also skill in handling the particular weapons with which they will be called upon to fight. Like most other questions, there is no absolute distinction between the two systems—their difference is a matter of degree. The parent to whom money is of no consequence may allow his sons an indefinite—that is to say, a classical—training in the assurance that they will afterwards get a surer and more intelligent grasp of the subjects upon which will depend their success in the battle of life. He is wise in allowing them to continue their general mental training if he is quite sure that the delay thus caused will not prevent them from making their way to the first fighting rank when they come to the front. Such a delay is not, so far as I can judge, detrimental to success in preparing for the professions. Rather is the delay a good thing in itelf, for various more or less indirect reasons which we need not discuss. But in the case of commercial life the handicap is, I gather, heavily in favor of those who are early in the field. The luxury of a classical education may prove costly, either by delaying the acquisition of business methods, or by causing the novice to hurry over and consequently to scamp the inevitable routine of business training. Every business is based upon knowledge of a specialized kind. It may be little more than bookkeeping, or it may include a considerable acquaintance with various branches of geography, science, modern languages, or other subjects. The successful merchant who is fond of asserting that his sons must begin their work young by 'learning to lick stamps' is thinking of the business machine which he has made, and which will continue to work so long as it is kept well oiled; he is not thinking of new developments, new competition, new needs for adaptation which will give fortunes to those who have brains and take them away from mere office machines. 'Licking stamps' was not the basis and source of the business methods which he himself developed, although he is fond of vaunting it as the open sesame of an ever-swelling banking account. It is a perverse and paradoxical expression of a half-truth; but its enunciation indicates a stupid incapacity of recognizing the causes of success in the past, and a still more stupid inability to recognize the trend of the forces which will make for success in the future.

Already innovations are being made in the training for commercial life. We shall probably see greater changes in the future. As a preparation for professional life—a 'training' in the athletic sense of the term—the classics hold the field. They develop the muscles of the mind, without attempting to give specialized skill in their use. The story of their attainment to this supreme position in education is a curious one. It is a story of blundering along the right road, reaching the right goal with the wrong end in view. During the Renaissance, men relearned the languages in which the knowledge of the ancients was enshrined, in order that they might extract their treasures of science and thought. With this fresh growth of learning, scholars felt the need of a common language in which to acquire knowledge and to express the results of their investigations. It was a necessity in the days of oral teaching and itinerant study. Equipped with Latin, an English student was equally at home in Cambridge, Paris or Padua. Frenchmen, Germans, Italians and Spaniards spoke and wrote in the same language as his teachers at home. Erasmus might 'learn in Oxford, teach in Cambridge,' correspond with all the scholars in Europe.

The first generous handfuls of classic wisdom snatched, scholars joined in a pedantic contest for the crumbs. This search required accurate knowledge of the languages which encased them. It was impossible to pay too much attention to their form. National, or rather university, rivalry instigated the representatives of learning to acquire a correct and elegant latinity in which to express their thoughts. It became traditional that a Scholar (with a capital S) was a man able to write Ciceronian Latin without the aid of dictionary or books of accidence; and this medieval tradition still holds in our public schools. When one reflects upon the purpose for which so much effort was originally spent, it is not a little humorous to find the effort continued for generations after the purpose has ceased to guide it. The results for which our ancestors strove have long been attained. The thought of the ancients has long been accessible to every one who can read English. Their science, which was living to the scholars of the Renaissance, is a historic curiosity, interesting merely as a stage in the progress of the human mind. We can attain all that the Renaissance sought for, and an infinity beside, without knowledge of either Greek or Latin. Yet in the epoch of Winchester rifles we still practise with flint locks. We stitch samplers in the days of sewing machines. A Runic inscription is scarcely more out of date than a Latin oration, since both are equally things of the past; both have equally fallen into disuse. Yet, with all the zeal of the Renaissance and with an equal appearance of seriousness, we spend years in preparing our boys to write Latin orations without the aid of books of reference. The *cache* of preserved fruits which the Renaissance discovered has long been consumed. Mental nutriment must now be sought for in the primal forest, with aid of axe and saw.

I should be very sorry to be misunderstood. It is impossible to exaggerate the magnitude of the debt which Europe owes to the Italian scholars of the fourteenth, fifteenth and sixteenth centuries. One needs to read the story of the rediscovery of the classics, as told by John Addington Symonds in 'The Renaissance in Italy,' to understand it fully. Latin at the beginning of the fourteenth century was so debased as to be almost forgotten; Greek was a lost tongue. Petrarch, Boccaccio and their successors restored Latin and rediscovered Greek. Dictionaries were compiled; codices compared; no effort was too great, no detail too petty if it helped to the comprehension of the meaning of the text or enabled the scholar to amend it when corrupt. It is—shall we say?—three centuries since this work was substantially complete. It is dangerous to fix a date, seeing that able men at our various universities are still engaged upon the task; but it can not be gainsaid that by the beginning of the seventeenth century scholars were in a position to read Homer and Aristotle, Virgil and Cicero, and to understand what they read. The seam of gold was exhausted, the mine had yielded up its hidden wealth; though it may be that for years to come the 'tailings' will repay the industrious work of those who are content with specks.

Yet the pedagogic method of preparing boys for the search remains the same. And, looking at the matter fairly, we readily acknowledge that, however empirical, the method is justified by its results. In the presence of the indisputably satisfactory effects of the method, it ought not to be difficult to trace the true relation between effects and cause. How is the success of a classical education to be explained? Let us decline to admit reasons which, if not absolutely false, are at any rate half untrue. A boy does not learn Greek and Latin roots because they will help him to understand his own language. He does not acquire these languages in order that he may absorb the science and thought of the ancients direct from the original text. He does not study Cicero in the expectation of some day writing Latin letters. For school-boys Greek and Latin are exercises in grammatical expression, and nothing more.

Among the many disingenuous arguments which have recently been advanced in favor of the maintenance of the compulsory study of Greek is the contention that it would be of inestimable value if properly taught. Its advocates are ready to disown the accumulated evidence of success, to deny results upon which they might safely rely, and to advocate a new venture. Greek, they say shutting their eyes to the teaching of experience, has hitherto been badly taught. It will answer all expectations if teaching methods are reformed. Too much attention has been paid to accidence, to scansion, to niceties of grammar. The subject has been made arid and infertile. Give more generous treatment a fair chance! Limit, says one class of apologists, the work in Greek to Homer and Herodotus. Let the boys do their translations with open dictionary and grammar. Do not delay so long over the introduction; hasten their acquaintance with the Hellenic heroes; let them come beneath their spell and experience their glamor. With equal vehemence another school contends, not for Homer and Herodotus, but for Plato's 'Republic' and the 'Memorabilia'; not for heroics, but for philosophy and art. The teaching of Greek is to have a new lease of life if it gives pledges that it will turn over a new leaf. These protestations of its advocates are pure cant. They known that neither legend, history, philosophy, nor art has influenced the vast majority of the boys who have thriven on a grammar-school training. Stultify the grammar, distract attention from accidence, syntax, prosody, and the value of the gymnastic is reduced to *nil*. Were it not for its humorous side, this change of front would be somewhat tragic. Boys are to be given the most sacred products of Greek thought as playthings. They are to be encouraged to express their opinion, in the vernacular of the dormitory, of Plato's metaphysics.

Because in the past such good results have been obtained by giving boys the shell without the kernel we are asked to believe that we shall do far better by giving them the kernel without the shell. We decline to recognize that it was not the nut which nourished them, but the exercise of cracking it which prepared their jaws for an attack on more nutritious food. There is no question as to the nourishing properties of the Greek kernel, but it must take its place with the English kernel as an article of diet; and there are obvious reasons for serving the English kernel first.

Do away with grammar—sheer, barren, jejune grammar—and you sacrifice the discipline which has caused our schools, for centuries after the purposes of the classical revival were accomplished, to cherish Greek and Latin as the most efficient instruments of education. We do not want a reformed teaching of Greek. Its reformation would be its destruction. Homer's clash of shields may stir a martial spirit. Plato's spiritualism may satisfy a yearning. But these emotions are not vehicles of education; they are its burdens. The valor, the philosophy, the poetry, the art of the Greeks contributed little to the making of the mind of the boy Johnson, the boy Macaulay, the boy Gladstone—however much these great scholars may have been inspired by Greek ideals in later life. We have Gladstone's own emphatic testimony that when at Eton he cared nothing at all about the Homeric gods, nor yet for many a year after he had left. He was at Eton under the famous flogger, Dr. Keate, at a time when Greek and Latin were the only subjects in the school curriculum, with "as much divinity as can be gained from constructing the Greek Testament, and reading a portion of Tomline on the Thirty-nine Articles, and a little ancient and modern geography." A few months after leaving school, he told Arthur Stanley that "Eton was a very good place for those who liked boating and Latin verses." It was the painful study of genders and cases, of dactyls and spondees, which contributed little by little to the building up of the logic-weaving machine in his brain. Let any one who can remember his school-boy days try honestly to recall the sentiments which accompanied the translation of a passage whether from the commonplace 'Anabasis' or an incomprehensible chorus. Let him feel again the emotions which a struggle with the language-puzzle evoked, and he will, if he can remember those days, find that the real meaning of the passage interested him not a whit. He was engaged in the by no means unattractive task of disarticulating a puzzle covered on one side with Greek characters, and so rearranging the pieces that when he turned the whole thing over on to its back he would find that the other side was English.

No argument could be more disingenuous than that of the would-be reformers who reply to those who, though they recognize the proved potency of the classics as educational instruments, nevertheless ask whether other subjects are not available, if not equally good as instruments, yet more prolific of practical results: "Although the classical vehicles have produced such admirable results, you will be amazed to find how much more beneficent they are if you substitute for the vehicles their contents." This is proposing a new venture. It is embarking upon a new scheme of education, which has neither experience nor tradition to support it. No rational man doubts the human interest of Greek letters; none doubts their moral and æsthetic influence; yet it may be open to question whether boys would not find the Arthurian legends as inspiring as the 'Odyssey,' and the plays of Shakspere as full of wit and precept as Sophocles, Æschylus and Euripides. However great the Greek example, there are reasons for endeavoring to form the character of English boys upon noble types from nearer home. Besides, the noblest masterpieces of the Greeks have been nobly translated. In English they will do more for a boy's mind than the 'Anabasis' will do in Greek. Boys, whatever their career, must have some literary training, say the apologists for the present system of teaching classics. This is my contention also, but I advance it with still greater emphasis. The literary training obtained whilst learning Latin and Greek is indirect, accidental. It is too serious a part of education to be thus left to chance. The grammar schools did not aim at giving to a boy the capacity of appreciating the literature of his own land. The old classical training was a drill, boys were taught to mark time, not to march. Generations of jurists and men of action have proved that when they left their grammar schools they were amongst the most vigorous of marchers. No one grudged the time spent in practising the goose-step, since there was no doubt as to the enhanced rate of progress when marching began. But times are changing. We will not say that competition is increasing—our fathers made the same assertion, and their fathers before them— but it is spreading. The public-school boy, notwithstanding the severe discipline of the classics, finds it hard work to hold his own against boys who have not had the benefit of this drill. Conditions have recently changed in a remarkable way. It is no longer a competition between boys all of whom have had either a grammar-school training or none at all. Public elementary schools, higher-grade schools, county schools, technical institutes are pouring their students into the upper ranks of the labor market. These students may be superlatively ignorant of classical grammar, but they have certain kinds of knowledge and certain forms of dexterity which make them hard to beat. A very large number of public-school boys are obliged to find a sphere for their more generalized attainments on the ranches of North America and the sheep runs of Australia and New Zealand. If, reluctantly, we abandon the classical drill which has secured our confidence by three centuries of undeniable success, we must be well assured that the tactics which we teach in its place are effective in the modern world.

That the study of language ought to occupy a predominant position in school life is overwhelmingly proved by grammar-school experience. I think, too, we must also allow that the fact that the school-boy never contemplates the classical languages as possible means of communication is in their favor.

The conclusion which appears to me to be established beyond all possibility of doubt, both by the positive evidence of the value of a grammar-school training and by the negative evidence of the difficulty which attends the acquisition of foreign languages in adult or even adolescent life, is that training in language is of the essence of education in early years. It is of the essence of education in early years because it is only then that it is effective; and, further, because training in expression means giving precision to thought. Thinking and expressing thought in words are so inseparably connected that widening the range of expression is equivalent to expanding the field of thought. The benefit of a classical education depends to a large extent upon the fact that for years a boy's finger is kept between the pages of a dictionary. He learns new words and comes to feel the importance of accurate definition. Words are the *tesseræ* of thought. Their arrangement in patterns is thinking. The mosaic of words shows by its richness or its poverty, its boldness or its uncertainty, its simplicity or its confusion and redundancy, the quality of thought. Expressing is thinking. The schoolmen of the Middle Ages attached so much importance to dialectic that they came at last to confuse success in the game of words with conviction: they looked upon the triumphant application of arbitrary rules of logic as proof. They apprehended the principles of thought; but failed because they mistook their own bylaws for natural law. The Popes of the Renaissance, who, like Eugenius IV., made the only test for high office in the Church an irreproachable Latin style, were not actuated merely by fashion or caprice: they mistook rhetorical ability for intellectual power, eloquence for wisdom. They were right in the idea, although too zealous in its application. Eloquence would be wisdom made manifest, if, in the multitudinous torrent of words, none were used in an ambiguous sense, none were superfluous, none were capable of replacement by others more congruous with the thought, none could be displaced from their position in the phrase without detriment to its sense.

It is not natural to children to make nice distinctions between approximately equivalent words. It is hardly second nature with grown men, especially if they be Englishmen. A boy finds that it is 'jolly beastly' to have to go back to school, and 'beastly jolly' to be coming home. He is always struggling back to barbarism—the use of gesture and stress in place of words. Even grown men have usually got to get somewhere. They have got to get their hair cut, or have got to get a book, have got a cold, or have got home. A very few *tesseræ* serve them to make the pattern of their thoughts, and their thoughts are in consequence crude and colorless. Children must learn words and must be drilled in their use. To attribute the proved success of classical education to its content appears to me a ludicrous and even wilful misreading of history; though I readily admit that even the average boy acquires something of valor, of patriotism, of esthetic sensibility, of emotional and intellectual sanity from contact with the mind of Greeks and Romans.

My doubt is as to whether, considering the modern conditions of life, the time has not yet come to replace Greek and Latin by modern and functional languages; to trust to their masterpieces for material with which to influence character; and, in the case of children who will never need to speak or read any language but English, to rely upon our own Shakspere for words, grammar and emotional tone.

If we but knew the most rudimentary principles of the psychology of speech! What form of language is best suited for the expression of thought? What form of language is most favorable to thinking? To those of us who have been through the ordinary grammar-school training the highly organized classical languages appear to be indisputably superior to their maimed and curtailed successors. We feel that gunpowder has not done more harm to the temples of Athens and Rome than the barbarians have done to Greek and Latin. We can not resist the impression that modern Greek and Italian, as they are but the ruins and vestiges of the languages in which Demosthenes and Cicero spoke, afford by comparison but miserable accommodation for thought. From our extremely small experience of the speech of the world we judge that, in the case of the few languages which we know, evolution has proceeded backwards: the better organized, and therefore, from the evolutionary standpoint, the higher, language has given place to the lower. But we are not justified in this conclusion. Language is essentially labile. The solvent of thought changes as the quality of thought changes. Philologists can but speculate as to the stages through which Greek acquired its complexity. Demosthenes did not help to regularize a single inflexion. He used the instrument of expression as it came to his hand. His language is not more, but less, ornate than that of Homer.

Greek and Latin were not made by cultured Greeks and Romans. The languages took form in the converse of their illiterate ancestors. Literature, upon which the beginnings of culture rest, closes language-building in the larger sense. Zulu is a more highly flexional language than Greek, with more elaborate endings, expressive of gender, number, case, mood, voice; with nicer laws of euphony. Probably the ancestors of the Greeks were, like the Zulus, a loquacious, quarrelsome, rhetorical race. The language of the Zulus is not great because it is complex in form. Every language becomes great when greatly used—Greek from Demosthenes's mouth; English from Milton's pen. The test of the elevation of a language, from the evolutionary point of view, is its simplicity, freedom from ambiguity, correspondence in the order in which words are used with the sequence in which ideas successively occupy the focus of consciousness. '*Amabo,* love, future, I,' is as swift an expression of thought as 'I shall love'; although it does not place the constituents of the idea in the order in which they pass across the mirror of my mind; my personality, in the case of such a general proposition, takes the lead. 'Lucretiam amabo,' no doubt, gives the order aright. But neither conglomerate allows of the inversion 'Shall I love?' Picking up the school-book nearest to hand, I have essayed the 'sors Virgiliana.' This is the sentence which my finger touched: "Relinquit animus Sextium gravibus acceptis vulneribus" ('De Bello Gallico,' VI.). It seems to me incredible that this sentence expresses the thought as it formed itself in Cæsar's mind: "Leaves it the soul Sextius by or to grave by or to received by or to wounds." Surely the idea of the personality of Sextius preceded the idea of some one fainting? What purpose is served by three times explaining that it was by or to (leaving it at the end an open question which) wounds? '-ibus,' if it does not impress the mind of the reader as the really important constituent of the phrase, is unduly heavy for a mere inflexion. Cæsar did his best with the language which his unlettered ancestors had bequeathed to him; but he was to be pitied in that his thoughts when they went abroad must walk in irons.

The only evolutionary tendency in language which we can recognize is this tendency towards analysis, towards dismemberment. So great an authority as Sir Charles Eliot, vice-chancellor of Sheffield University, who perhaps knows a greater variety of languages than any other man, from Portuguese to Russian, from Turkish to Japanese, languages of Central Africa and of the Polynesian Islands, tells me that he considers that this progress favors thought. Gender, number, case hamper language, restrict its flexibility, impede thought. A monosyllabic root-language, such as Chinese or Burmese, is a swifter and more precise solvent of thought than are the highly inflected Bantu tongues. If this be true—and it does not seem to me open to doubt—it is easier to think in English than in Latin.

The drilling of boys in languages of lower type than their own must have some strange, mysterious sanction to justify its use. There must be an explanation of the undeniably good results which have followed this generalized, purposeless training—results which caused those who were best qualified to judge to cling to it with such tenacity. It is not of the schools of to-day that I am speaking. So many reservations and qualifications would be necessary that I could not hope that my thesis would be approved. The schoolmaster has for some years been engaged in the process of sloughing his skin—a process which he seems very reluctant to see accomplished. The rattle at the end of his tail which so easily subdued the pupils under him has gone. Yet he still clutches at his gold and purple scales. The lineaments of Greek gods and Roman orators are still to be distinguished in the folds of the sadly crumpled case with which he is so unwilling to part. He feels strangely cold clad in nothing but his native wisdom. It is not of this half-accomplished rejuvenescence that I wish to speak. Let us go back to the golden days of grammar schools. It is not as long ago as Mr. Gladstone's youth. Many of us of a younger generation experienced their heroic rule. Assuredly it was not the content of the classics which proved in our case of educative value. It could not, for the reasons I have stated, have been the languages, as such. I have but one explanation. It was the rebound on to English which the classical drill produced. We were ceaselessly searching the pages of the dictionary. We were learning new words. We were studying English syntax. In my opinion any foreign language would have served equally well to produce this rebound. Or it might have been brought about by the intelligent paraphrasing, construing, analysis of English authors. The last course would probably be the shortest road to the supreme goal—skill in the use of the language in which we think and with which we speak.

HYGIENIC REQUIREMENTS IN THE PRINTING OF BOOKS AND PAPERS

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THE cheapness and universal prevalence of printed matter, and the general enactment of compulsory education laws which fasten the reading habit upon all, give the problems of the hygiene of reading a universal and very great significance. This reading habit, when one thinks of it, has become perhaps the most striking and important artificial activity to which the human race has ever been molded. A very considerable part of most people's waking time, whether in childhood or in adult life, is taken up with the contemplation of printed or written symbols. One is seldom out of sight of some sort of printed or written matter, and the automatic functioning of the reading habit keeps one reading away at whatever appears, though it be but the silliest advertisement in a car or on a concert program.

And yet this reading habit is an intensely artificial performance, involving for both mind and eye and nervous mechanism, most delicate of all products of evolution as these are, constant repetitions of functionings which were not foreseen in their evolutionary development. I discuss elsewhere the nature of these unusual functionings and the causes of the fatigue and degeneration which have resulted from reading, and which must continue more or less until the organs become adapted to these requirements of modern civilization. The dangers from the strain on mind and eye and nerves, in reading, will be materially lessened if the schools, especially, will honestly enforce certain hygienic requirements that are now generally agreed upon, and statements of which are easily accessible in such recent books as Shaw's 'School Hygiene,' or in the more comprehensive work of Burgerstein and Netolitzky.

Probably the most important and most feasible means of lessening the fatigue and strain of reading is by bringing about, so far as possible, that all books and papers shall be printed in such type and arrangement as shall fall within certain recognized limits of hygienic requirement. As to some of the requirements which should be made of the printer we are still uncertain, and further experimental investigation rather than the present excess of opinion is in order and is cryingly needed. Of some requirements we can now be certain, and these should be enforced rigorously, in the printing of school-books and government publications, at least. If enforced here, they will tend to extend to all printing.

In studying the psychology and pedagogy of reading during some years past, the writer has been thrown in contact with the experimental work bearing upon the establishment of norms for printing. The present article is an attempt to sum up the results of investigations made thus far, and to state the requirements which they warrant us in making of the printer.

The size of the type is perhaps the most important single factor. The experiments of Griffing and Franz showed that fatigue increases rapidly as the size of the type decreases, even for sizes above eleven point, or above a height of 1.5 millimeters for the short letters like v, s, etc. The various investigators are generally agreed that this should be made a minimum for the height of the short letters. Matter printed in this size of type is read faster, and individual words are recognized more quickly, than where the type is smaller. Besides, Griffing and Franz found that the effect of insufficient illumination is less marked with the larger type. Preferably the height of the small letter should be somewhat above the minimum stated, though when the height is much above two millimeters Weber's experiments indicated that the speed of reading is decreased.

The thickness of the vertical strokes of the letters should not be less than .25 millimeter, according to Cohn, preferably .3 millimeters, according to Sack. This thickness of the letters has been found by Javal and others to be a very important factor in increasing legibility and thus in decreasing fatigue. Griffing and Franz found, however, that hair lines might form parts of the letter without decreasing the legibility provided the other parts were thick. They find it possible, however, that such hair lines may increase fatigue. The minimum of thickness stated above should be insisted on for the main lines.

The space within the letters, between the vertical strokes, should not be less than .3 millimeter, according to most investigators. Sack finds .5 millimeter to be preferable. There is probably little to be gained by increasing the distance between the letters beyond that which is usual in the better printed books of the present time. Burgerstein and Netolitsky would require that this distance should be greater than the distance between two 'neighboring ground strokes' of a letter, and Sack would make the minimum distance .5 to .75 millimeter. Burgerstein and Netolitzky would not allow more than six or seven letters per running centimeter, and would require as much as two millimeters between words. With these requirements Sack is in agreement. It should be remembered that any very u n u s u a l s e p a r a t i o n of the letters of a word is distracting and should be avoided.

These minimal forms as stated by Burgerstein and Netolitzky should be made requirements, except that possibly the distance between letters is not so important as they urge. The minimum of six or seven letters per running centimeter is a convenient approximate gauge which can be quickly applied and is not too stringent.

Griffing and Franz found that legibility increased somewhat, though not greatly, with increase in the distance between the lines, with the leading, as it is called. Cohn thinks it important that there should be a minimum interlignage of 2.5 millimeters, and Sack requires the same. Javal does not find that interlignage increases legibility appreciably, and thinks that the space used for interlignage had far better be given to an increased size of letter without interlignage. The leading is doubtless a mistake when the size of type is below the requirements made above. The size of type should by all means be increased instead, as this is by far the most important of the factors conditioning fatigue. However, a certain amount of leading should be required in school books, at least, but hardly more than Cohn's minimum of 2.5 millimeters.

As to length of lines there is a general consensus in favor of the shorter as against the longer lines, with a tendency to favor 90 millimeters as a maximum, some placing the maximum at 100 millimeters. The latter is doubtless too high. Javal, who has studied the matter very carefully, insists that the maximum should be considerably below even 90 millimeters. He names as one of the principal causes of fatigue in reading, and as a cause tending to produce and aggravate myopia, the considerable amount of asymmetrical accommodation required as the eye moves along a long line, the amount increasing always with the length of the line. Even with the page squarely before the reader, unless he makes constant and fatiguing movements of the head while reading, the reading matter is always farther from one eye than from the other, except at a middle point, and the reader strains to accommodate for both distances, especially for objects held so near as is the page in reading.

Against the long lines is also to be urged the difficulty and distraction incident to finding the place at each turn to the next line, increasing always as the lines are longer. Besides, the longer lines require a greater extent of eye-movement for a given amount of reading. This comes from the fact, verified by various experimenters, that the eye does not traverse the whole line in reading, but begins within the line and usually makes its last pause still farther within, reading the first and last parts of the line in indirect vision. The amount of this indentation tends to be a constant amount irrespective of the line's length, and is consequently a larger proportion of the line's length in the shorter lines. There is thus an important lessening of eye-work in using the shorter lines. Indeed, I found that readers could read matter printed in lines of 25 millimeters in one downward sweep without any lateral movement of the eyes. With lines 30 millimeters long, the lateral movement was sometimes almost *nil,* and seemed to be due mainly to habit. In reading such lines in this way the eye's extent of movement is hardly more than one fourth or one fifth the amount needed for the same matter when printed in long lines.

When the shorter lines, generally, more words were read per fixation than with the longer ones. A magazine column having lines 60.5 millimeters long was in one case read at the rate of 3.63 words per fixation, while columns having lines 98 to 121 millimeters long required a fixation for every two words. Lines of a length approximating 60 millimeters are usual in newspapers and in my experiments were read with a minimum of eye-movement. The makers of the modern newspaper have felt the reaction of readers more, perhaps, than have the makers of books. Out of this experience has evolved the present practise of printing newspapers in narrow columns, the line-lengths of which are perhaps as near the optimum as can be determined at present, when we consider that much shorter lines give great inconvenience to the printer.

For books, also, the newspaper line-length is near an optimum so far as ease and speed of reading are the conditions to be considered. In the case of large books where the question becomes one of printing in one or in two columns per page the latter alternative should undoubtedly be chosen. For books of ordinary sizes a somewhat longer line may be used where this will contribute to convenience or beauty; but a book should not be used whose lines are more than 90 millimeters in length, and somewhat shorter lines are generally to be preferred.

One of the great advantages of the shorter lines is that they constantly permit the reader to see in indirect vision what his eye has just passed as well as what is just coming. Though the words of this related matter may not be clearly perceived, they furnish visual clues which keep the reading range further extended at each moment, a most desirable condition for all reading and especially for fast reading or for skimming. With such lines a hurried reader may glance straight down a page with only an occasional short stop, and may yet be sure that he has gathered the gist of everything.

Dr. Dearborn, in experiments made recently at Columbia University, found that the eye makes its longest pause near the beginning of the line, thus permitting a general preliminary survey of the line. A secondary pause of more than average duration is made near the end of the line, perhaps partially in review. He finds that lines of only moderate length facilitate these general surveys better than the longer lines, and finds also that they facilitate a rhythmical regularity of eye-movement, both being conditions which contribute to speed and ease of reading. His tests showed that such lines (a little longer than newspaper lines) were read at greater speed and with shorter pauses than lines of twice the length.

Dearborn argues, and correctly I think, in favor of uniformity in the length of lines, particularly in books for children. The reader drops quickly into a habit of making a regular number of movements and pauses per line, for a given passage, and broken lines confuse and prevent the formation of such habits. However, a *slight* indentation every other line may, he thinks, be of distinct advantage.

Dearborn thinks that a line of 75–85 millimeters combines a good many advantages, and we are certainly safe in putting 90 millimeters as a maximum, with a preference for lines of 60 to 80 millimeters.

The smaller books which can be easily held in the hand during the reading are to be preferred, and on the whole have grown in popular favor. The larger books usually have to lie on a support, which exposes the letters at an angle, greatly lessening their legibility and producing the equivalent of a material decrease in the size of type.

As to the forms of particular letters, many changes are cryingly needed. However, further investigation is needed before we are warranted in requiring changes of the printer. We know that such letters as t, z, o, s, e, c, i, are comparatively illegible. C, e, and o are often confused with each other, and i with l, h with k, etc. This confusion can be avoided by making certain changes in these letters, and their legibility can be increased. Certain excellent recommendations of changes in particular letters have been made by Javal, Cohn, Sanford, and others.

However, there are many things to be considered in making such changes, and further thorough and mature investigation is needed before any letter is permanently changed. The whole matter should be placed in the hands of a competent specialist or committee of specialists, to be worked over experimentally and advised upon in the light of the psychology of reading, the history of typography, esthetic considerations, the convenience of printing, and the lessons of experience generally. Changes should not be made on the single basis of experiments upon the comparative legibility of isolated letter-forms. A letter whose legibility in isolation is bad may sometimes contribute most to the legibility of the total word-form. Studies now being made of the comparative legibility of letters as seen in context will doubtless throw light on this point. The subject is too complex to permit the adoption of recommendations that are based on study, however careful, of any single aspect, or on anything that does not include a careful study of all the factors. It is high time, however, that there should be a rationalization of these printed letter-forms that have come down to us in such a happy-go-lucky fashion, and it is to be hoped that either the Carnegie Institution or some department of research in a well-equipped university may take hold of the matter and see that the work is thoroughly done.

Among further printing requirements that are important and that should be insisted on, the letters should have sharp clear-cut outlines, and should be deep black. The paper should be pure white, but without gloss, the latter being especially trying to the eyes. According to Cohn and Sack the paper should have a minimum thickness of .075 millimeter. Paper of a slightly yellowish tinge is probably not injurious and is preferred by Javal. But in general the legibility depends on the contrast between the black of the printed forms and the white of their back-ground, and colored or gray papers lessen this difference and thus diminish legibility. Pure white light gives the greatest legibility. The print of one side must not show through from the other, and the printing must be so done that it will not affect the evenness of surface of the other side.

It is important that wall charts and maps should not contain more names than are absolutely necessary for purposes of instruction, and that these should be in large clear type; or the most important names for reference at a distance and by classes may be in the large type, with the others in type fulfilling the requirements for school-books and for use by individuals at the ordinary reading distance from the chart or map. Burgerstein and Netolitzky advise that school maps should not present the physical and political features on the same map, in the interest of greater legibility. Names printed on colored map surfaces need to be in larger rather than in smaller type than that used in books, if legibility is to be maintained, as any other back-ground than white means diminished legibility.

The writing upon slates is considerably less legible than that upon good white paper. In the case of blackboards the surface is apt to be gray after erasing, and this, of course, lessens the legibility very considerably. It is important that the blackboard surface be deep black, without gloss from reflection so far as this is possible; and that it be kept clean, avoiding the gray effect. Teachers and pupils should acquire the habit of writing on the blackboard in a large plain hand, as the greater distance at which the writing is read and the usually diminished legibility makes this of importance, and especially in the primary school grades.

In stating the requirements above, I have had in mind the needs of adult readers and of the older school children. The younger children must have a type much larger than the minima there stated. The reading of young children has not been sufficiently studied to warrant a final statement of what should be required in the printing of their books. As the most usable approximate statement of what may properly be insisted on, and for the sake of uniformity, I quote here the requirements made by Shaw in his 'School Hygiene.' These requirements are none too stringent, except that sometimes some of the leading may well be sacrificed in favor of a type that is a little larger, for the third and forth grades especially.

"For the first year the size of the type should be at least 2.6 millimeters and the width of leading 4.5 mm."

"For the second and the third year, the letters should not be smaller than 2 mm. with a leading of 4 mm."

"For the fourth year the letters should be at least 1.8 mm. with leading 3.6 mm."

For some grades succeeding this the type should be kept well above the minimal requirements for adult readers.

Examinations of the school books in use in Germany, Russia, and other European countries, made at various times and places, have shown that usually from fifty to eighty-five per cent. of the books came short of hygienic requirements. American books are somewhat better, but include very many that are very bad. Even when the principal part of the book is in good type, there will often be large sections printed in a type so small as to be very injurious. The dictionaries and other books of reference have notoriously small print, and those with the smaller and poorer types should be mercilessly discriminated against. As Shaw rightly says, "Principals, teachers, and school superintendents should possess a millimeter measure and a magnifying glass and should subject every book presented for their examination to a test to determine whether the size of the letters and the width of the leading are of such dimensions as will not prove injurious to the eyes of children. If every book, no matter what its merits, were rejected if its type were too small, the makers of such books would very quickly bring out new editions with a proper size of type."

THE WASTE OF CHILDREN

By Dr. Geo. B. Mangold
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LESS than two hundred years ago not more than one fourth of the children born in London ever reached their fifth year of life. The rest were ruthlessly swept aside and died without adding a single iota to the sum of human service. It is a matter of utmost importance to know under what conditions an advance in population is secured. The beginnings of national life in Europe were accompanied by energetic efforts to augment the number of each national group. Necessarily the strength of a nation depended largely upon the size of its population. Despite these efforts, the practical results were lost in the many adverse circumstances which operated to neutralize their effects. A comparatively slow increase of the population of nearly every European country before the last quarter of the eighteenth century was the natural result. Every civilization, however, whether old or new, has purchased progress at considerable cost. Lives, property and happiness have been sacrificed to attain this coveted goal. Civilization spells economy. It means a fuller utilization of our powers, faculties, and our mental and physical equipment, no less than a more capable use of the productive forces of nature. The more primitive a society, the more immediate and absolute is its subjection to environment. From this thraldom civilization is gradually releasing us, and to-day we stand partly above our environment and in a measure mold it by determining its character, and forcing its adaptation to our peculiarities in addition to our own increasing adaptability to its changing conditions.

Probably in no other field of human activity has man's former ignorance been more lamentable in its consequences than in that of rearing children—the future parents of the race. Even the slow increase of savage tribes is purchased at a tremendous expenditure of energy, and the number of infants and little children whose physical and economic cost is never compensated for by useful and productive lives has been appalling. A recent investigation of the Bontoc Igorrote in the Philippines indicates a mortality of 60 per cent. before the age of puberty is reached. Such people have risen but little above their natural environment and are quite subject to its rigors and destroying processes. Decreasing cost characterizes advancing civilization, yet throughout the eighteenth century the European population, being largely ignorant or indifferent, was blighted by the influence of a destroying environment.

The progress of the industrial world for the last century has been unparalleled and almost incredible. The organization of industry, the rise of combinations, the fuller utilization of the forces of nature, our marvelous inventions, the increasing division of labor and greater insistence upon bodily vigor are devices calculated to lessen the cost of production of goods. In certain industries, for example the oil and packing industries, such a state of perfection has been reached that little if any waste products remain, although twenty years ago a large residue was continually lost. The decrease of unnecessary cost and labor is the goal of industry. Apply this principle to the cost of propagating the human race and what do we find? Is not the tax and strain upon the expectant mother too great to permit even an apathetic society calmly to ignore the just claims of dying infants for the opportunities which make for a life of usefulness and service? The eighteenth century began to answer this question, but even the twentieth has not yet given a satisfactory reply. The darkness and austerity of a civilization finds no mean measure in its infant death rate. In this respect great progress has indeed been made, but it is an advance far outstripped by the progress of industry. Social progress has proved the laggard, but may yet make amends for past neglect.

The wholesome changes of the past one hundred and fifty years are indications of great possibilities. The conditions in London only reflected those existing throughout all England which lived beneath the pall of the blighting destroyer of babes. In recent years three fourths of the children in London have lived to the age of five. As late as 1761, however, 50 per cent. of London's population perished before reaching the age of twenty. To-day half the people of England do not die until after the fifty-fourth year has been reached, and the infant mortality—the death rate for children under one year of age—had fallen in 1903 to the creditable figure of 144 per 1,000 births for the seventy-six great towns of England. Even this rate is somewhat above the average for the entire country. In Prussia during the decade 1751 to 1760 only 312 children out of every 1,000 births survived to the age of ten. At this age the child is still an economic cost; it depends upon others and yields no surplus to society. Yet two thirds of the entire population failed to reach an age of social usefulness, and perished after body, mind and resource had been spent to give it a proper place in human society. The record of a later decade, 1861–70, shines in comparison with the former, but is still fraught with fears for the future. Six hundred and thirty-three individuals were being saved out of every 1,000—a promising decline, but one not measuring up to the hopes of social amelioration. Is it any wonder that former mothers, full of grief and anguish at the sight of lifeless babes, believed more largely in a Providence whose decree was inexorable, who gave and who took away? From this morbid fatalism the medical advance of the past one hundred years and the strenuous efforts of men with human sympathies applying themselves to problems of social betterment have freed the majority of our kind, and the doctrine is properly relegated to the category of abandoned beliefs. The triumph over small-pox has been one of the results contributing to this end. Formerly it was a scourge carrying away large portions of the population. Two thirds of all new-born children are said to have been attacked, of whom one eighth or more regularly died. A frightful mortality thus obtained, and this was minimized only through the introduction of vaccination, which in some countries increased the average duration of life as much as three and one half years. Owing to this direful experience of the past, foreign countries are still more insistent than we are upon employing that method of preventing the disease.

France has paralleled the record of England, and, when once inaugurated, improvements and reforms succeeded with astonishing rapidity. During the first seven years of the last century, the number of male inhabitants reaching an age sufficient to subject them to conscription was but 45 per cent. of the total number born, yet by 1825 the percentage had risen to 61—a most healthful gain in the proportion of those attaining adult life. Backward Russia has been equally a laggard in its attention to the moral and social requirements which result in a low infantile death rate. At the beginning of the nineteenth century it permitted one third only of the children of its peasants to grow up to maturity and as few as 36 per cent. of its population reached the age of twenty years. Even here science has made advance.

The great changes in the social and economic conditions of the European people have had a marked effect upon the growth of the population. As the power and ability of men to control the conditions of their environment were increasingly realized, beneficent effects were everywhere noticeable. To recuperate the strength lost in war and disaster, men urged the device of a decreased death rate instead of striving as formerly for a larger percentage of births. An observing demographer in the first half of the last century thus expressed himself, 'Population does not so much increase because more are born as because fewer die.' Yet the population of nearly every country has increased wonderfully during the past century, and in view of the new conditions of its expansion what a fine commentary upon the advance of modern civilization and the practical efficiency of government this tremendous fact has been!

From this former dismal reality with its merciless slaughter of helpless babes we in America have made much progress. Accurate data for the earlier years of our history are wanting, and at present very few of our states keep a careful registration of births and deaths, although a large number of our cities are now recording their vital statistics with increasing care. The absence of city life with its baneful consequences somewhat relieves us from the charge of infanticide, but the exposure and the rigors of the Atlantic seaboard worked its many hardships. Data for New York before 1850 show that 27 per cent. of its infants died before reaching the age of one, but the rate for Boston was comparatively low, being recorded as less than 20 per cent.—a figure exceeded by many cities at the present time. Conditions in Massachusetts have been relatively favorable and its vital statistics indicate that the death-dealing influences of the close of the century were more fatal than those operating at the beginning of the Civil War. This observation, discouraging as it is, is somewhat softened by the favorable changes in the death rate of children below the age of five. These records prove that a constantly growing percentage of children live to that age, and once having reached the fifth year the chance of a life of future usefulness is considerably increased. The expectation of life in Boston according to the reports of the Census Bureau was in 1900, 9.74 years greater for the child of five than for the infant at birth. This difference is, moreover, diminishing, as it certainly must if mortality is being checked. A similar difference in the English expectation of life argues for similar rates of mortality for children at these ages. The low death rate of children between the ages of five and fourteen insures the succession of a large majority to an adult age. Civilization demands that this be a constantly increasing proportion and that the fewest possible number of lives be wrecked in the adolescent stage. The energies of society must be expended in many various directions where the need is most urgent, and where reforms are clearly possible. That society should waste vast portions of its accumulating energies is not only deplorable and a hindrance to social advance, but is a mark of criminal neglect. Where waste of lives can be avoided, as the decreasing mortality of children shows, there inaction by society is unpardonable.

In spite of the existence of many plague spots, where innocent infants are barbarously slain, the statistics set forth by the twelfth census furnish ground for a growing optimism. Although a large percentage of inaccuracy obtains, the figures are sufficiently reliable and comparable to indicate quite faithfully the hopeful tendency toward child saving. The tables for the registration area show that the infantile death rate fell from 205 per 1,000 births in 1890 to 165 in 1900. In the former year one out of every five infants died, although allowance should be made for unrecorded births. In the latter year one out of every six—a gain of approximately 20 per cent. For children under five the gain is even more favorable, thus demonstrating an increasing success in bringing children through the most critical stages of life and in lessening the necessary waste. The thousands who die are not the victims of the law of natural selection. It is not largely an elimination of the unfit. More definitely than ever before is it being established that most children enter life with an endowment of native vitality sufficient to weather the ordinary conditions of adversity. The great variations in death rates after the first few months are due largely to postnatal influences, to the social and economic environment in which the child is caught, from which it has no appeal, and which make or mar its future.

The wide range of infant mortality from the lowest rates of the healthful country districts to the fearful massacre of infants in the crowded and unsanitary portions of our larger cities indicates the magnitude of the task still before us. That eminent authority on vital statistics—Dr. Farr—estimated that the annual unnecessary deaths of infants in England during the decade 1851–60 numbered more than 64,000. The conditions in respect to food, water, cleanliness, malnutrition and midwifery, he regarded as the chief causes of this needless loss of life. The proportion of loss suffered from these sources has since undoubtedly diminished, but the aggregate number is greater now than then. The effect of the various factors which influence the rate of our annual loss of children is marked in the difference between our urban and rural rates, and between those of white and colored children. The comparative healthfulness of rural life is attested to by ample evidence. It is indicated not only by the farmer's long expectation of life, but also by the low death rate prevailing among his children. A comparison of the chances of the child in the country and in the city is a proof of the wholesome influence of a favorable environment. It suggests the need of increasing effort to raise the city to the high level of rural vitality. In the registration states the infant mortality for white children varied in 1900 from an average of 116 per 1,000 births in the rural districts to 180 in the cities. The urban rate seems to be more than 50 per cent. higher than that observed among the country population. For every two infants dying in the country, three are sacrificed in the city districts. Yet this is not everywhere the case, nor is it necessarily so. In parts of Germany the rural death rate is enormous. Especially is this true in the agricultural districts of southern Bavaria, where an almost hopeless infant mortality is recorded. The rural region of Prussia shows higher rates than do our American cities, but they still possess a slight advantage over Prussian urban centers. This heavy mortality indicates a social lethargy and backward conditions among the agricultural population, which in spite of many natural sanitary advantages remains handicapped by unfavorable social and industrial surroundings; and these preclude proper attention to the wants of children. In England, again, the rural rate is generally below that of the cities and considerably below the infant mortality of the mining and industrial centers. Compared with Scotland, the entire country has a decided disadvantage. Yet the nature of the problem is somewhat simplified on reflection that the results of an earlier investigation of death rates disclosed the fact that the mortality of the sons of peers before the age of six was less than one third of that obtaining among the rest of the population.

On the other hand, many English and American cities record rates lower than the average rate prevailing in the rural district—an eloquent argument for the possibilities of many of our cities. The statistics of 1881–90 for Massachusetts showed average variations during the decade from 111 to 239 deaths per 1,000 births. The former rate marked the healthfulness of a residential town, the latter portrays the conditions existing in an industrial center. Yet in some of the manufacturing towns where no tenement-house evil existed the infantile death rate was comparatively low. Other American cities show variations equally wide, and even within the same city the most contrasting conditions continue to exist. The lowest rates for cities of considerable size are recorded for Seattle, St. Paul and Minneapolis. The prevailing rates are approximately 100 deaths per 1,000 births, according to their records, which some authorities have, however, pronounced as giving too favorable a showing. Many of the larger cities double the death rate for infants, while in numerous southern cities it rises to almost criminal proportions. John Spargo has pointed out the differences that may exist within a single city and exemplifies them by quoting a rate of 94.4 per 1,000 in the Back Bay district of Boston against a proportion of 252.1 for one of its poorer districts. Some of our own cities have clearly blazed the path of progress. Buffalo and Rochester, N. Y., have during the decade 1890–1900 made notable reductions in the percentage of loss from infant mortality. Better inspection of the milk supply and increased watchfulness of contagious diseases, especially those of children, have contributed to this end. In Buffalo compulsory vaccination of school children was instituted and circulars distributed which contained instructions concerning the care of children. Among cities which have done noble service during the same decade in reducing the mortality of children under five are Lowell, Lawrence and Haverhill, Mass., Newark and Jersey City. All these had high rates of mortality and present rates still exceed those of many of our cities in which conditions are naturally more favorable. The many remarkable ameliorative changes of the past fifteen years only indicate the possibilities whose limits have not yet been reached, while much pioneer work still remains to be done. In view of the declining rates and the wide variations in them, the existing differences refuse to be explained away, and we can not assign them all to natural causes. Some cities, especially those of the Pacific coast and the mountains, possess natural advantages, yet cities under similar conditions show most striking contrasts. Still worse, the same city may contain the extremes of progress and of neglect. Hence our efforts can not be abated until they have wrested from the destroyer every vestige of his ill-gotten power. It is the province of science and the duty of society to force from nature what she can not rightfully claim, and to leave her the remainder only. Serious changes in our methods and policies may be involved, but these must be molded according to this undying purpose. The miserable conditions still prevailing among the American negroes are evidence of this need. An infant mortality in Charleston where the majority are negroes, of 419 per 1,000, and in other southern cities of more than 300 is little better than barbarism. At first thought the racial factor might be assigned as the cause of this great difference between the vitality of white and colored infants, but this defence of social inaction is unworthy of our race. A closer investigation shows that the death rate in the rural portion of the registration area was 218.9 for colored infants, but that the city rate stood at 387. This difference roughly measures the advantages of a more favorable social environment. Were the care of the children a more capable one and the conditions making for degradation and disordered birth rate ameliorated, this wide difference would not exist, and the rates in the rural districts could be further reduced. Remembering the former pitiless slaughter of white infants, our hopes for the negro need not be abated. Indeed the colored infant mortality of the rural districts in 1900 was but little above that of white infants for the entire registration area in 1890. What hopes then might not knowledge and prosperity offer! Three eighths of the negro infants of the cities dying annually! To their mothers they are nothing but a curse, a cause of pain and sorrow. A cross-section of a darker age resides in our midst. Yet 150 years ago the children of our ancestors died with an equal facility.

Climate and certain phases of nature have so far proved impregnable to the genius of our race. Their disadvantages may have to be borne for years and centuries, but for acclimated peoples an infant death rate of 307 per 1,000, as was recorded for the Philippines for 1903, is only an evidence of an inferior and brutal civilization. To counteract such death rates and provide for a liberal increase of population a birth rate must be excessive if not inhuman.

These facts disclose a cause of the rapid increase of population during the last century. The increased vitality of infants has made it possible. With their rate of mortality cut in two a new era might naturally arise. The English birth rate was higher in 1851 than in 1891, but the percentage of excess of births over deaths was greater in the latter year. The fluctuations between these two dates indicate the highest net increase as occurring during the decade 1871–80, but the significant lesson taught is seen in the possibilities which even a lower birth rate may yield. The continued triumph of knowledge and humaneness draws comfort from the recent history of other European nations. A comparison of birth rates, death rates and excess of births between the period 1861–80 and 1885–96 shows that in nearly every important European country birth rates have declined. Yet no alarming tendency to depopulation has manifested itself, because the decreasing death rates permit a greater net increase of lives. Consequently the rate of increase was augmented during this period in Hungary, Prussia, Austria, Italy, Holland and Belgium, but declined slightly in England, France and Scandinavia. Some of these nations have a mortality which is even now considered excessive and which, if proper measures are inaugurated, can be considerably reduced. Hungary with a birth rate in recent years of 40.4 had a smaller percentage of increase than Sweden whose rate was only 27.1, while the Russian mortality was higher than England's birth rate and but little below that of Germany.

Several observations may be made in respect to the foregoing facts:

First and foremost: The physiological advantage of contributing to a growing population by means of lowering the death rate rather than by increasing the rate of birth. Mental anguish, physical and economic cost, would thus be reduced to a minimum. It is the method of enlightened civilization. The burden of our mothers is not lightly borne, let them enjoy the fruits of their suffering.

Second: The marvelous reduction in the former rate of infant mortality indicates what social reform may accomplish, and what a saving of lives may follow.

Third: The differences between rural and urban death rates suggest the character of the environment needed for the increased healthfulness of cities.

Fourth: The contrasting conditions disclosed in single American cities and the gratifying results of sanitary measures, milk inspection, and advancing intelligence pave the way for a growing hopefulness.

Realizing the importance of the principles which our vital statistics establish, society can insist more strenuously upon preventive reforms. It can reduce the waste of infant lives, and conserve our potential population. Let us ascertain whether our population is sufficiently fecund by giving every new-born babe a fair opportunity for life. Whether 'race suicide' will then have a national aspect, society will be better able to judge. Certain classes are indeed chargeable with a low birth rate, but for the masses the more important problem is a diminishing infant mortality. When the best of society's efforts in this direction have been realized, then a solid basis for subsequent reasoning concerning the probable future of our race will have been established.

A BLAZING BEACH

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IN December, 1905, an account was given in *Science*[1] of a remarkable phenomenon which was described as 'A Blazing Beach' as observed at Kittery Point, Maine, and an attempt was then made to bring forward an explanation which would satisfactorily account for all the observed facts. During the past summer an opportunity was offered for a reexamination of the locality, and it was then possible to obtain some additional facts which tend to strengthen the conclusions originally reached. It was also learned that a second but smaller conflagration had occurred in the same place at a somewhat later date. It is therefore felt that a further account of the facts will be of interest at this time.

The accompanying photograph, taken during the past summer, shows the precise area within which the conflagration developed. The beach at the point where the fire occurred is composed of a barrier ridge at its upper margin, made up of pebbles of varying sizes. This ridge is thrown up and maintained under the action of southeast storms, at the angle of repose for the material of which it is composed, and about half-way down its outer face, the high water mark of spring tides is clearly indicated by patches of sea-weed. This high-water mark corresponds approximately to the level of the interior area where the trees are to be seen growing, and which is frequently flooded in times of severe southeasterly storms. The base of the barrier ridge is indicated by the line of sea-weed which defines the high-water mark of the ordinary neap tides. From this point the beach, consisting of pebbles, continues outward and downward at a somewhat sharp incline for a distance of about seventy-five feet, when the pebbles are replaced by sand, the first patch of which is seen just above the line of water. The photograph shows half-tide.

The sand formation extends from the edge of the water outward with a very gentle slope, and thus makes shoal water for a considerable distance beyond the mass of loose rock seen on the extreme left. With the exception of the barrier ridge, the beach extends laterally for a distance of one hundred and seventy-five to two hundred feet between the solid ledges shown in the photograph. The general constitution of the shore along the river front is solid ledge, and this particular locality may be described as a pocket which has become filled with

[1] N. S., Vol. XXII., pp. 794–796. 1905.

sedimentary deposits consisting of clay, sand, sand and gravel, coarse gravel and finally large pebbles.

Over the outer portion of the sandy bottom, also for great distances beyond, as well as up and down the river wherever extensive silting has developed the formation of muddy bottoms, there is an abundant growth of eel grass (*Zostera marina*) which, together with other débris of a similar nature, is continually washed upon the beach, broken up by the combined action of the waves and sand and gradually buried in the latter, so that each year the deposit of organic matter is increased by definite though rather slight increments.

From these data it will be observed that some special significance attaches to the fact that the fire, on two separate occasions, was strictly confined to the beach, and that it did not in any way extend over the limiting areas of rock.

On the evening of Friday, September 1, 1905, the guests in the hotel, the piazza of which may be seen on the extreme right of the photograph, were startled by the appearance of flames rising from the beach and also from the surface of the water. The tide was about one hour lower than shown in the photograph, so that a very considerable portion of the sand was uncovered. The conflagration occurred between seven and eight o'clock in the evening and lasted for upwards of forty-five minutes. It was accompanied by a loud and continuous crackling noise, which could be distinctly heard one hundred yards distant, due to the rapidly recurring explosion of bubbles of gas as they came to the surface of the sand or water. At the same time there was a very strong liberation of sulphúrous acid gas, which penetrated the hotel, drove the proprietor and his staff from the office and filled the other rooms to such an extent as to cause great inconvenience to the guests. So great a heat was developed that the sand could not be held in the hands, while sand placed in a tumbler with water and then stirred, liberated bubbles of gas which ignited upon coming in contact with the air. On this occasion the fire developed over that portion of the sand which had been exposed by the falling tide, and it also extended out over the water for a distance of thirty or forty feet.

On the evening of Wednesday, October 4, 1905, as reported by a reliable observer, the phenomenon was repeated with identical features, except that instead of occupying the entire area between the rock formation on each side, it was restricted to the area where the two boats are lying. It therefore occupied probably less than one fourth the area of the first conflagration.

It is difficult to estimate the height of the flames on these two occasions, since the conditions under which the fire occurred would tend to give an exaggerated value. It is probable that in general the flames were not more than three or four inches in height, and this would be a reasonable estimate when arising from small bubbles of gas. But, as stated in the original account, the flames attained a maximum of about one foot, and this may readily be conceived of as possible in cases where there was an unusual discharge of gas.

The explanation originally offered appears to fulfill all the observed conditions, and upon further study there seems to be no good reason for regarding it as other than valid. The flames are to be considered as resulting directly from the spontaneous combustion of light carburetted and phosphuretted hydrogen at the moment of their contact with the air, and these flaming gases in turn ignited the associated sulphuretted hydrogen, which gas then gave rise to secondary features such as the bluish, luminous flame and the sulphurous acid fumes. Examination showed that there was no adequate basis for any of the various attempts to explain the phenomenon as the result of volcanic action. the disruptive effects of a blast of fifty tons of dynamite two miles away, or the decomposition of fish, the phosphorescence of which was not clearly differentiated from the main features of the conflagration.

While it is a comparatively simple matter to reach the conclusions thus far given, it is altogether a more serious problem to ascertain the origin of the gas, the greatest difficulty being to determine how gas could be produced in sufficient quantity to give rise to a conflagration of the extent and duration observed. It is perhaps justifiable to conclude that the gas must have been accumulating at a slow rate for a long time, otherwise there would not have been such a large volume; and it is also reasonable to suppose that, unless liberated as fast as formed, smaller conflagrations should have been noted on previous occasions. But the local records, so far as the memory of 'the oldest inhabitant' extends, can show no similar occurrence in the past. Such storage of gas would be quite possible in a deposit of coarse gravel, pebbles and coarse sand, overlaid by a layer of fine, wet and compact sand acting as a retaining layer. It is possible, also, that the accumulation of gas may have been brought about under slight pressure, so that the earthquake of the day before may have furnished just that shaking which was necessary to disturb the conditions of equilibrium and liberate the gas at a critical moment. The occurrence of a smaller conflagration one month later may or may not harmonize with this idea, but it does seem to emphasize the suggestion of the storage of large volumes of gas which were not wholly set free on the first occasion. In endeavoring to account for the source of the gases, three explanations have been found to be possible:

1. The area protected by the barrier beach is, as already noted, somewhat depressed. It extends from the beach to a stone wall which may be seen just beyond the two elm trees; and from the square house to an almost equal distance beyond the corner of the hotel piazza on the right. It was originally occupied by Sir William Pepperrell as a deer park, but later it was utilized as a tan-yard.

Some years since two drains were laid through this area in such a way as to make sections of its entire extent. The ditches were carried down through the superficial deposits to a clay formation, which is presumably of Pleistocene age, and this clay formed the foundation for the tan vats located in the surface stratum. The excavations disclosed numerous, scattering fragments of leather and tan bark, sufficiently ample to make the former use of the locality quite manifest; but nowhere were there any local accumulations of a nature or in such quantity as to explain the formation of gas in any appreciable volume. Moreover, had gases formed there they would most naturally have worked upward through the permeable soil and thus they would have escaped directly into the atmosphere rather than have taken a seemingly impossible course down a slope for a distance of some two hundred feet or more. It is, moreover, about eighty years since tanning operations were carried on in that locality, and the conditions of the soil render it unlikely that any very large amount of gas could be stored there for that length of time. The theory that the gases had their origin in the decomposing organic débris of a tan-yard must therefore be dismissed as untenable.

2. The Atlantic coast line, probably throughout its entire extent, is undergoing depression at the rate of about two feet per century. This leads to a variety of well-defined changes, among which may be mentioned the gradual silting up of protected areas, the submergence and final burial of forests and the formation of marsh lands. Nowhere are these changes better exemplified than in the neighborhood of Rye in New Hampshire, and Kittery and York in Maine, for the reason that they are developed within areas of such size, and within periods of such short duration, as to be brought well within the experience of individual observers.

Wherever silting occurs, and more particularly where marsh lands are formed, large volumes of gas are generated and may be readily observed rising to the surface of the water at more or less frequent intervals. In the case of the silted areas the gas is obviously the product of vast quantities of Zostera, supplemented by other forms of organic remains, both plant and animal. In the marsh lands the gas is the normal end product in the decay of the lower portions of the marsh turf. This gas generally accumulates in the turf and in the silt below, sometimes being held in pockets in such large volume that when suddenly liberated its effects are overpowering. For one who is at all acquainted with such marsh lands it is not difficult to reach an explanation as to the production of gas in sufficient volume and of the proper kinds to produce all the phenomena under consideration. It was therefore felt that there might be a small, buried marsh beneath the beach at Kittery Point, and an attempt was made to solve the question by direct examination, with the following results:

For a depth of about seven inches the beach consists of a fine and compact sand worked into a layer of great firmness. Below this, as far down as it was possible to go without the use of special methods, the deposit consists of large beach pebbles mixed with coarse sand. So far as a buried marsh was concerned, the results were entirely of a negative character, but from the fact that there is a deposit of clay farther down, as well as from critical studies of the formation of marsh lands and of silted areas, prosecuted during the past summer, there seems to be great probability that one or both of such formations may lie beneath the beach at a horizon which could not be reached. In the absence of positive data, however, this source of gas must be

A BEACH AT KITTERY POINT, MAINE; the scene of a conflagration, September, 1905.

neglected, and the third alternative must be brought under consideration.

3. In making a section of the lower beach, as already recorded, it was observed that the superficial layer of sand, that which is directly acted upon by the water, consists of about one inch of freshly washed, fine sand with which are mingled numerous fragments of marine plants and even fragments of land plants, most of them in a fresh state but broken into small pieces by the recent action of the water and sand. Below this is a deposit of sand about six inches thick. This layer rests directly upon a mixture of beach pebbles and coarse sand extending to an unknown depth. It is the six-inch, or second, layer in which interest chiefly centers, since we find it to contain all sorts of organic débris, including marine algæ, fragments of drift wood and bones of land animals. It in fact constitutes the general receptacle for all those organic remains which have been ground up in and transferred to it by the surface layer. It is clear that while this second layer may remain of approximately equal thickness, its organic content is con-

stantly augmenting and at the same time undergoing decay. This is finally expressed in the deep black color of the stratum, by the carbonized fragments of marine algæ, driftwood and even of bones, showing that within this zone there are developed precisely those conditions which would be productive of gases in considerable volume.

It is this last explanation which affords the chief basis of a tentative hypothesis respecting the origin of the gases producing the conflagrations, though it is also highly probable that other volumes of gas originated at a greater depth in a buried marsh, or in silt deposits which were subsequently overlaid by a pebbly beach.

This phenomenon, while peculiarly interesting in itself, serves as a means of explaining the possible origin of many obscure forest fires for which it has hitherto been impossible to find an adequate explanation, and in considering this important aspect of the question we are not to overlook the possibility of accounting for fires which have occurred in past geological ages, as well as those of recent date.

In 1905, Arthur Hollick directed attention to the presence of charred wood in the Cretaceous deposits at Kreischerville, Staten Island, New York, and drew the inference that since man was not in existence at that time, the fire must have been due to some natural agency, probably lightning. This explanation, however, was not regarded by him as wholly satisfactory, and it was adopted tentatively because of the absence of positive testimony in any other direction, and also because the occurrence of fires in widely separated localities of approximately the same geological age could not be accounted for through the medium of such an agency.[2] In a more recent communication on this subject,[3] the same author observes that some of the fragments of burned wood are charred on the outside only, while other smaller fragments are completely charred throughout. "These latter occur in greatest abundance in connection with layers or seams of yellowish, sandy clay. The prevailing colors of the Cretaceous sands and clays throughout this locality are white and gray, while the yellow layers are of quite limited extent and appear to have been burned or baked. It seems therefore reasonable to infer from this association of materials, that the charred wood was not deposited with the clay in the condition of charred wood, but that it was fresh material at the time of deposition and was subsequently burned in place, thus baking the enclosing clay."

"A careful study of the Kreischerville deposits indicates very clearly that the original conditions of deposition must have been strikingly similar to those described as existing at the Kittery Point Beach. The layers of vegetable débris and sand, intercalated in the clays are comparable to the sandy layer of black, organic débris

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[2] *Proc. Nat. Sci. Assn. S. I.*, Vol. IX., 1905, pp. 35, 36.

[3] *Proc. S. I. Assn. Arts and Sciences*, Vol. I., 1906, p. 21.

in the beach, and it is reasonable to infer that wherever such conditions prevail, similar phenomena of combustion may occur," and he therefore finds that the explanation of the Kittery phenomenon is not only satisfactory in that case, but that it affords a satisfactory solution of the way in which fires originated in Cretaceous time.

In 1900, Dr. G. F. Matthew of St. John, N. B., described a bog in the vicinity of that city which gave evidence of the occurrence of a forest fire about two thousand years ago, this estimate of age being based upon the age of growing trees, the thickness of individual layers of peat, and the relative density of different layers, together with the known rate of formation as determined by the age of trees *in situ*.[4]

Evidences of ancient forest fires are to be met with in other bogs to which Dr. Matthews directs attention, and it is altogether probable that they had a similar origin. The agency of lightning is excluded as not tenable because of the thorough knowledge of the bogs in question for a period of from 6,000 to 9,000 years, and from the evidence at hand the conclusion is reached that they must have been due to the early inhabitants of the district who knew nothing as to precautions against the spread of fire, and who would have been but little likely to have adopted them had they been known.

Upon a careful examination of the account given by Dr. Matthews, it would seem that the situation of the burned wood within the area of a bog is a distinct argument against man as the active agent, because if he had been the cause of the fires, evidence of them should be found in the more elevated areas about the shores of the bog, but of this the account gives no information and we are left to infer that only the bog itself was involved. Furthermore, the features of deposition and the general character of the various strata, point with some force to the idea that we have here another example of a fire due to the spontaneous combustion of gases generated in the inferior strata where decomposition was evidently active.

Apart from its more strictly scientific aspects, the occurrence of such a conflagration as that which developed at Kittery Point gives a most singularly striking manifestation of a phenomenon which, as developed upon a very limited scale, has been a matter of common knowledge for a very long time, and has been woven into the folklore of various countries, where it has often played an important part in the life of the common people. Among English-speaking people the well-known 'corpse-candle,' 'Jack-o'-lantern,' and '*ignis fatuus*,' take a most conspicuous place in the superstitions of the less educated portions of the community, both in Europe and in America, even to the present day, although the scientific explanation has long since been accepted and understood.

[4] 'A Forest Fire at St. John, about 2,000 Years Ago,' *Can. Rec. Sc.*, VIII., 1900, pp. 213–218.

Occidentals, however, by no means enjoy a monopoly of the romances and legends which may be gathered about the flickering flame of the elusive *ignis fatuus*. Very few countries have developed so rich a folk-lore as the Japanese, and the very fertile imaginations of her people have not failed to apply many weird explanations to an object capable of so many interpretations, sometimes investing their 'ghost-fire' with the same attributes that attach to our 'corpse-candle'; again attributing to their 'demon-light' the possession of singularly baleful influences; or in the 'badger-blaze,' 'fox-flame' and 'dragon-torch' finding a medium for the most varied witchery, sometimes comical, sometimes serious, and not always devoid of tragic results.

According to accounts by Brinkley, it is related of the 'badger-blaze' that it wanders in the Kawabe district of Settsu on rainy nights, and that uninitiated rustics, mistaking it for the glowing pipe of an ox-driver, hold commune with the badger, who is at all times a sociable fellow, and have even lit their own tobacco at his and puffed it in his company. Or again, at the base of the Katada hills, in the province of Omi, there lies a lake from whose margin on cloudy nights in early autumn a little ball of fire emerges. Creeping toward the foot of the mountains, it grows as it goes, sometimes swelling to a brilliant sphere three feet in diameter, sometimes not developing to more than a third of that size, but always when it rises to the height of a man's stature above ground, showing within its glow two faces, to which gradually the bosses of two naked wrestlers, struggling fiercely, attach themselves. It takes its way slowly and harmlessly to the recesses of the hills, but resents, with superhuman force, any attempt to interrupt its passage. Once a wrestler of unconquered fame waited at midnight for its coming, and sprang to grasp it as it passed through the mists. He was hurled to a distance of ten or twelve yards and barely escaped with his life.

The fox is an animal particularly addicted to assuming a great variety of shapes and disguises, often entering into and taking possession of people for evil purposes, or otherwise imitating various natural or artificial objects, thereby giving rise to great confusion or even distress, as witness the phantom train on the Tokaido railway some years since, which so terrified and confused an engineer as to nearly cause a disaster. Among other disguises of this animal is that of the so-called 'fox-flame,' which is assumed at night in dangerous and solitary places. The initiated, however, may readily overcome the spells of the 'fox-flame,' since all that is necessary is to join hands so as to leave a diamond-shaped opening between the crossed fingers. By blowing through this opening in the direction of the light, at the same time repeating a Buddhist formula, it is possible to extinguish the witch-fire at any distance.

THE PROGRESS OF SCIENCE

LORD LISTER

LISTER was born on April 5, 1827, and his eightieth birthday has been the occasion for congratulations from all parts of the world. A large and influential international committee has resolved to commemorate the occasion by publishing in quarto form a collection of his scientific works. A deputation waited on Lord Lister on April 5 to ask his approval of the plan, at which time he expressed his apprecia-

LORD LISTER.

tion and willingness that the plan should be carried into effect.

The great discovery of the antiseptic method in surgery was first announced in 1867. In an address before the meeting of the British Medical Association held in Dublin in that year, Lister said: "When it had been shown by the researches of Pasteur that the septic property of the atmosphere depended, not on the oxygen or any gaseous constituent, but on minute organisms suspended in it, which owed their energy to their vitality, it occurred to me that decomposition in the injured part might be avoided without excluding the air, by applying as a dressing some material capable of destroying the life of the floating particles."

Lister used carbolic acid as an antiseptic, and although the methods were at first imperfect, the results were remarkable. The wards of which he had charge in the Glasgow Infirmary were especially infected with gangrene, but in a short time became the healthiest in the world; while other wards, separated by a passageway, retained their infection. Like all great discoveries, Lister's antiseptic methods have been extended and improved, being now rather aseptic than antiseptic, the precautions being largely directed toward preventing infection by sterilization. It must be remembered that in addition to the work for which Lister is famous, he has made important contributions to surgery and the practise of medicine.

Lister's father was a member of the Society of Friends; a man of business, but also engaged in scientific work. He was a fellow of the Royal Society, as are also his son, Arthur, and his grandson, J. J. Lister, the brother and nephew of Lord Lister. Lister married the daughter of the eminent surgeon, Professor Syme, to whose chair at Edinburgh he succeeded. He has no heir. Lister became assistant surgeon at the Edinburgh Royal Infirmary in 1856, and moved to Glasgow as professor of surgery in 1860, returning to Edinburgh in 1869. He then became professor of clinical surgery in King's College, London, in 1877.

Lord Lister has been honored by the government by being raised to the peerage; by his fellow men of science by his election to the presidency of the British Association for the Advancement of Science and of the Royal Society; by his colleagues in medicine and surgery by the naming in his honor of the Lister Institute, one of the most important institutions in the world for medical research. But his highest honor is the use in every hospital of the world of the antiseptic system of surgery that he discovered. This treatment has relieved endless suffering and saved innumerable lives, and has permitted the extension of surgery to operations which without it would have been impossible. It is indeed the foundation on which modern surgery is built.

THE CENTENARY OF THE BIRTH OF LOUIS AGASSIZ

On May 28, 1807, Jean Louis Rudolphe Agassiz was born in the Canton of Freiburg, Switzerland, his father being pastor of the protestant parish of Motier. The centenary of his birth is being celebrated at Harvard University and at Cornell University. At Harvard there is a gathering of his former pupils with addresses by President Eliot and Professor Niles. At Cornell, where Agassiz was nonresident professor, a commemorative address is to be made by Professor Burt G. Wilder. Professor Niles and Professor Wilder were among the group of eminent naturalists who were pupils of Agassiz, which includes, in addition to his son, Mr. Alexander Agassiz, Bickmore, Clark, Hartt, Hyatt, Lyman, Morse, Packard, Putnam, Scudder, Shaler, Stimpson, Tenney, Verrill and Ward.

A biographical sketch of Agassiz will be found in the fourth volume of The Popular Science Monthly. In

LOUIS AGASSIZ.

the thirty-second volume will be found an article on 'Agassiz and Evolution,' by Professor Joseph Le Conte, and in the fortieth volume an article on 'Agassiz at Penikese,' by President David Starr Jordan. As a tribute we print here his portrait and the facsimile reproduction of a letter addressed by him to Professor Joseph Le Conte, one of the members of a family distinguished for their contributions to natural science.

My dear Sir,

I answer your letter of the 14 inst. without delay. I shall be happy to see you in Cambridge, as soon as convenient to you. It will give Mrs Agz. & myself great pleasure to welcome you & Mrs Le Conte in our house; and ~~will~~ shall be delighted to renew our acquaintance with your brother & his wife. As my collection of Echinoderms is now in good order I would advise you to take with you all your specimens of that class to identify them with those already described & to describe the new ones. I have all the books relating to those animals & you might make quite a valuable paper with yours. My collection of Echinoderms is the largest in the world, not excepting that of the Jardin des plantes & the British Museum. I shall be able to give you a copy of the Catalogue of Echinoderms; the Monographs are a larger work 4°, with many illustrations, containing however thus far only the Salenia, Scutella, Anatomy of Echinus, & Galerites.

As to a compressor I think nothing equal to thin glass plates & well practised fingers. I am very glad you have at last got your microscope; the more you use it, the less will you want all those accessory facilities, which constitute only time taking incumbrances.

I am sorry to say I have been obliged in consideration of my health to resign my connection with the medical college in Charleston, hoping that a northern winter would restore me to my former energy. The meeting in Cleveland was particularly successful in the mathematical phys. section.

How is Dr. Jones? Can you collect your freshwater fishes for me & send some of my circulars to your friends at the South & West?

Sincerely your friend

L. Agassiz

Cambridge 20th August 1853.

Prof. Jos. Le Conte, Athens, Ga.

PREVALENCE OF THE PLAGUE IN INDIA

From January 1 to March 16, 1907, there have been 254,033 deaths from plague in India, a marked increase upon the returns for the 1906, when the deaths from plague for the whole year amounted to only 316,550. The number of deaths from plague in India during the years 1904, 1905 and 1906 were respectively 1,023,815, 946,-558 and 316,550. The number of deaths from plague in India from January 1 to the middle of March during the years 1904, 1905, 1906 and 1907 amounted to 253,903, 316,801, 70,761 and 254,033, respectively. The number of deaths during the current year are therefore, to the middle of March, somewhat above the number in 1904 during the year, when over 1,000,000 died of plague; they are, however, considerably fewer than the deaths which occurred during the corresponding period of 1905, but this does not hold for the latter part of March. The outlook is, therefore, not hopeful. Since plague appeared in India in the autumn of 1896, the number of deaths from the disease in India to March 16, 1907, has been 4,767,141.

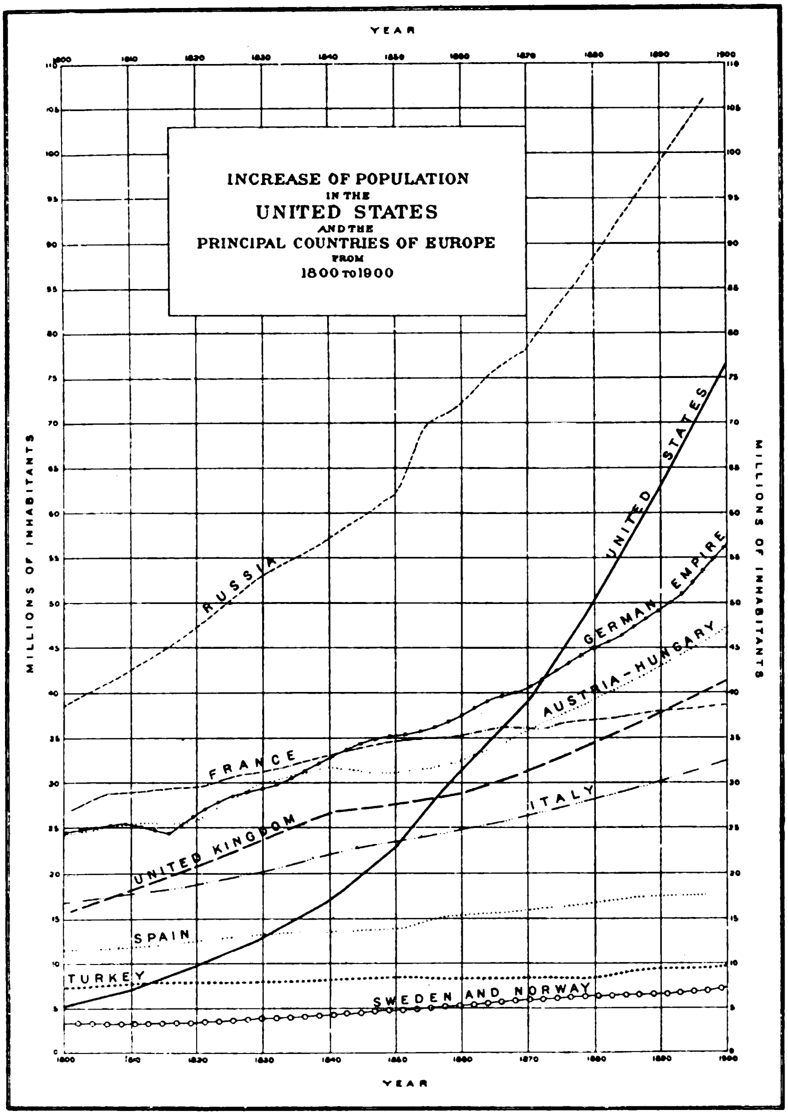
These facts, for which *The British Medical Journal* is the authority, are appalling. Even in India, a human life may be assumed to be worth $1,000, and it seems probable that the expenditure of $4,767,141,000 by the British government, partly spent on definite measures in India and partly on scientific investigation would forever abolish the plague and possibly control all epidemics. There is now much political unrest in India, and this might not be allayed even by the abolition of the plague. But the present liberal government and its secretary of state for India should appreciate their responsibilities and their duty.

THE POPULATION OF THE UNITED STATES.

The Census Office issued some time ago a 'Statistical Atlas,' prepared under the supervision of Mr. Henry Gannett, geographer of the twelfth census, which gives many interesting tables and plates, illustrating the progress of the United States in population, vital statistics, agriculture and manufactures. We reproduce here a diagram showing the increase of population during the last century in the United States and in the principal countries of Europe.

The growth of population here, compared with that in European countries, is most striking. Only Russia has a curve at all comparable to that of the United States, although the German empire shows similar tendencies during the past decade. The vast population of European Russia, which has about doubled in sixty years, shows a very constant increase, and this will be accentuated should the death rate be reduced to the proportions normal in other countries. The results of the increase of the people of Russia will probably be the most important factor in the history of Europe during the coming century. Great Britain has maintained a constant increase, and it may be an unwarranted assumption to suppose that this will soon be checked by the decreasing birth rate and the physical deterioration due to predominant town life and factory employment. The slow growth of the French population during the century and its present stationary condition, the birth rate being almost as low as the death rate, give much anxiety in that country. There were in 1903 about 20,000 fewer births than in 1902, and 32,000 fewer than in 1901. In some departments the birth rate is far below the death rate; thus in 1903 there were in Gers 3,333 births and 4,792 deaths; in Lot-et-Garonne, 3,946 births and 5,718 deaths, etc.

The curve showing the increase of



THE POPULATION OF THE UNITED STATES.

population in the United States during the past century seems to indicate a boundless growth. But a different interpretation appears to be possible. The percentage of increase for continental United States was remarkably constant in each decade from that beginning in 1790 to that beginning in 1850. For each period the percentages are as follows: 35.1, 36.4, 33.1, 33.5, 32.7, 35.9 and 35.6. But in the census of 1870 there was a sudden drop in the percentage to 22.6, which is attributed in part to the civil war and in part to defective enumeration. There was a rise in 1880 to 30.1, followed by a fall to 24.9 in 1890 and to 20.7 in 1900. The decrease in percentage from 1860 to 1900 was at the rate of 3.45 per decade. Should this decrease continue the percentage of increase would cease in 1950 and thereafter a decrease in population would ensue. The population of the country would then be 88 millions in 1910, 101 millions in 1920, 111 millions in 1930, 119 millions in 1940 and 123 millions in 1950, at which time the population of the country would have reached its maximum and would thereafter decline. It is of course unlikely that this will be the future of our population. The percentage of increase will almost certainly become smaller, but probably with increasing slowness. The data from 1860 to 1900, however, give indications of these results, and they are more probable than the boundless increase of population of the country and of the world which has sometimes been predicted.

SCIENTIFIC ITEMS

At the meeting of the National Academy of Sciences, held in Washington last week, President Ira Remsen, of the Johns Hopkins University, was elected president to succeed Mr. Alexander Agassiz. The vacancy in the vice-presidency thus created was filled by the election of Dr. Charles D. Walcott, secretary of the Smithsonian Institution.—Members were elected as follows: Joseph P. Iddings, professor of petrology, University of Chicago; Harmon N. Morse, professor of chemistry, Johns Hopkins University; Franklin P. Mall, professor of anatomy, Johns Hopkins University, and Elihu Thomson, Thomson-Houston and General Electrical Companies.

Oxford University has conferred its doctorate of science on Dr. A. Graham Bell.—Dr. Franz Boas, professor of anthropology in Columbia University, was presented on April 16 with a volume of researches by his colleagues and former students in honor of the twenty-fifth anniversary of his doctorate.—Dr. Francis Galton has been appointed to deliver the Herbert Spencer Lecture for 1907, at Oxford, and proposes to lecture on 'Probability, the Foundation of Eugenics.'

Mr. Edward B. Moore, assistant commissioner of patents, has been appointed commissioner to succeed Mr. Frederick I. Allen, who has resigned.—Count de Montessus de Ballore, of Abbeville, France, one of the leading authorities on earthquakes, has accepted a call from the government of Chili to establish for them a seismological service of the first rank. This action on the part of the Chilian government is a direct result of the disastrous Valparaiso earthquake of last August.

Among gifts to educational institutions the following may be noted: Princeton University has received from donors whose names are for the present withheld a gift of $1,200,000, for the erection and endowment of two scientific buildings—one for physical science and one for biology and geology. In each case the building will be erected as a cost of $400,000, and $200,000 is provided for equipment and maintenance.—By the will of Edward W. Currier Amherst College receives the sum of $500,000. Two legacies are released by Mr. Currier's death; one of $180,000 to Williams College and one of $100,000 to Yale University—Mr. John D. Rockefeller has given to the University land fronting the south side of Midway Plaisance of the value of $1,500,000.—Barnard College, Columbia University, has been made the residuary legatee of the estate of Miss Emily O. Gibbes. It is estimated that the college may receive $750,000—Miss Anna T. Jeanes, of Philadelphia, has created an endowment fund of $1,000,000, the income from which is to be applied toward the maintenance and assistance of elementary schools for negroes in the southern states.

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NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS

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AMERICAN MEN OF SCIENCE

A BIOGRAPHICAL DIRECTORY

EDITED BY J. McKEEN CATTELL,

Professor of Psychology in Columbia University; Editor of *Science* and of *The Popular Science Monthly.*

[FROM THE EDITOR'S PREFACE]

This biographical directory of AMERICAN MEN OF SCIENCE was begun as a manuscript reference list for the Carnegie Institution of Washington, which made an appropriation of $1,000 toward the clerical and office expenses. It is hoped that the publication will be a contribution to the organization of science in America. There is here given for the first time a fairly complete survey of the scientific activity of a country at a given period. As a reference book for the field it covers, it may be even more useful in academic circles than MINERVA or WHO'S WHO IN AMERICA. But the chief service it should render is to make men of science acquainted with one another and with one another's work. There scarcely exists among scientific men the recognition of common interest and the spirit of cooperation which would help to give science the place it should have in the community. It is fully as important for the nation as for men of science that scientific work should be adequately recognized and supported. We are consequently in the fortunate position of knowing that whatever we do to promote our own interest is at the same time a service to the community and to the world.

There are included in the directory the records of more than four thousand men of science, and it is believed that the entries are tolerably complete for those in North America who have carried on research work in the natural and exact sciences. A star is prefixed to the subject of research in the case of about a thousand of the biographical notes. These are the thousand students of the natural and exact sciences in United States whose work is supposed to be the most important.

The blanks were sent in all to about ten thousand who might have contributed to the advancement of science and from the replies the names included have been selected. As many as four requests were sent to those who it was believed should be included, when they did not reply to previous applications. Proofs of all the biographies were submitted for correction — a second and a third copy having been sent when necessary — and revised proofs were sent after the corrections had been entered.

It was intended that each entry should contain information, as follows:

(1) The full name with title and mail address, the part of the name ordinarily omitted in correspondence being in parentheses.
(2) The department of investigation given in italics.
(3) The place and date of birth.
(4) Education and degrees.
(5) Positions with dates; the present position being given in italics.
(6) Temporary and minor positions.
(7) Honorary degrees and other scientific honors.
(8) Membership in scientific and learned societies.
(9) Chief subjects of research, those accomplished being separated by a dash from those in progress.