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SOIL WASTAGE

By Professor THOMAS CHROWDER CHAMBERLIN, Ph.D., LL.D., Sc.D.
UNIVERSITY OF CHICAGO

THE invitation to give thought to the conservation of resources that affect our future, appeals to me with almost personal force, for my studies of the past decade have led to the belief that the era of the earth's future habitability is vastly greater than we have been wont to think. We have grown up in the belief that the earth sprang from chaos at the opening of our era and is plunging on to catastrophe or to a final winter in the near future. Quite at variance with this, I have come to believe that the earth arose from a regenerative process and that it offers a fair prospect of fitness for habitation for tens of millions of years to come. If this be true, it is eminently fit that our race should give a due measure of thought to the ulterior effects of its actions.

It is one of the latest conceptions of geology that climatic conditions have been of the same order as at present from early eras, in the large view, in spite of some notable variations, and that this uniformity is the result of a *profound regulative system* which has sufficed to keep the temperatures of the earth's surface and the constitution of the earth's atmosphere within the narrow range congenial to life for many millions of years. As a result there has been no break in the continuity of land life since it came into being eras ago. It appears, further, that the sources of supply of the vital elements are still adequate, and are likely to be so for long ages, that the regulative system is still in effective control, and that a vast future of habitability may fairly be predicted, subject only to some contingencies of collision or disturbing approach of celestial bodies. Whether you are prepared to accept so large a view of the habitable future or not, I trust you will strike hands with me in the conviction that the probabilities of the future are at least so great as to render imperative the serious consideration of our obligations toward it.

It is a familiar geologic deduction that for long eras rains have fallen on the lands and soils have grown in depth, while the surface has been washed away. Soil-production and soil-removal have run hand in hand, and yet they have been so controlled by the adjustments of nature that no large part of the surface has been swept bare enough to altogether exclude vegetation. More than this, it appears that the usual adjustments of nature *make rather for increasing fertility of soil* than depletion. It is true that at intervals deformations of the earth have intervened giving mountainous heights and precipitous surfaces from which the soil-product has been washed faster than it could be produced; and desert conditions have also intervened locally; but these diastrophic effects are perhaps rather rejuvenations necessary to the preservation of the continents than destructive episodes. Whenever such heights and slopes have been raised, the atmosphere and its waters have at once begun to grade them down, to cover them with soil, and to give to them a renewed habitability. So, in these and other ways, the gifts of the great past now present themselves to us as the product of a marvelous system of control which has checked excesses and forced movement toward the golden means in which have lain productivity and congeniality to life. Thus has come our inheritance of a land suitable for habitation, of a soil-mantle of great fertility, of a precipitation conducive to productiveness, and of a system of streams endowed with great possibilities of water-foods, of power and of navigation.

We do not hesitate to enter into the inheritance, but what part shall we take in the regulative system that produced and maintains it? How shall we cooperate with nature in rendering conditions still more serviceable to ourselves, and in transmitting a still greater inheritance for our successors? Clearly we may use the proper revenues of our inheritance, but surely we should not rob our successors of their share in it.

Let us turn at once to the basal factors in the problem, the rainfall, the soil-formation and soil-wastage, the special theme of this hour. The rainfall may be regarded as an inherited asset, the soil is clearly an inherited asset, even a little soil-removal is an advantage, but reckless soil-wastage is a serious error. Soils are the product of the atmosphere and its waters modifying the rock surface. When they have aided the air in producing soil by rock decay, the atmospheric waters may pass either into plants or back to the surface through the soil and out by evaporation, or they may pass on down to the groundwaters and thence into the streams, furnishing there the basis for water-foods, for power and for navigation. Here is a good work—soil-production—followed by advantageous courses of the water both up and down. On the other hand, the rainfall may rush away on the surface as a foul erosive flood, wasting soil and plant-food, gullying the surface, flooding the valleys, filling the reservoirs, sweeping out the dams, barring the streams and clogging the deltas. If it shall be found that nearly all the rainfall should go into the soil and thence into the under-drainage, coming out slowly and steadily by seepage and by springs into the streams, clear and pure, these streams should present nearly ideal conditions for water-food, for water-power and for stream-navigation. An ideal solution of the soil problem may therefore solve the greater part of the whole complex of problems of which navigation is the last term. It may thus prove to be the *key* problem. It is clearly the *initial problem,* for it attacks the rainfall when it first touches the earth.

To see more definitely if it be the key problem, we must turn to details, and yet, with the brevity that is imperative, we may only look at major details, passing by a multitude of special cases, some of which are even exceptions.

While soils are formed by the atmosphere and its waters acting upon rock (aided by plants and animals), soil surfaces are carried away by wind and wash. At any instant, then, the depth of the soil measures the lag of removal behind production. We hasten to note that the addition of new soil below and the loss of exhausted soil above are alike tributary to permanent fertility, and clearly the best results spring from *the proper ratio* of addition at the bottom, to wastage at the surface.

We have as yet no accurate measure of the rate of soil production. We merely know that it is *very slow.* It varies obviously with the kind of rock. Some of our soils are derived from material already reduced to a finely pulverized condition. Such are the lowland accumulations from highland wash. Such also is the glacial drift, rock-flour rasped from the face of the rock by the glacial file and ground up with old soils. Soils may be developed from such half-prepared material with relative rapidity, but observation shows that even in these cases, when the slope is considerable, wind, wash and cropping remove the surface much too fast for stable fertility. For average rock, under the usual conditions of our climate, the common estimate of natural loss and gain has been a foot in 4,000 to 6,000 years, which includes channel-cutting and bank-undermining. This seems to me too rapid a rate for ordinary soil production under normal conditions. Without any pretensions to a close estimate, I should be unwilling to name a mean rate of soil-formation greater than one foot in 10,000 years, on the basis of observation. If we allow 40,000 years for the formation of the four feet of soil next to the rock over our average domain, where such depth obtains, it will probably be none too conservative. To preserve a good working soil-depth, with such an estimate, surface wastage should not exceed some such rate as one inch in a thousand years. If one chooses to indulge in a more liberal estimate of the soil-forming rate, it will still appear, under any intelligent estimate, that surface wastage is a serious menace to the retention of our soils under present modes of management. Historical evidence enforces this danger. In the Orient there are large tracts almost absolutely bare of soil now, which formerly bore flourishing populations. Long-tilled lands generally bear testimony of like import. Much more than mere loss of fertility is here menaced; it is *the loss of the soil-body itself,* a loss almost beyond repair. When our soils are gone, we too must go, unless we shall find some way to feed on raw rock or its equivalent. The immense tonnage of soil-material carried out to sea annually by our rivers, even when allowance is made for laudable wash, and for material derived from the river channels, is an impressive warning of the danger of excessive soil-waste. Nor is this all; the wash from one acre often buries the fertile portion of another acre, or of several. Sometimes one's loss is another's gain, but all too frequently one's loss is another's disaster.

If the atmospheric waters may not run off the surface freely without serious menace, where may they go and what may they do consistent with our welfare? The answer lies in a return to the study of the origin and internal work of soils. For necessary brevity, let us neglect all secondary soils, or overplacements, and consider simply the origin and activities of primary soils derived from primary rocks. The action of air and water in producing soil from such rock is partly chemical and partly physical. Certain rock substances are made soluble and become plant food or plant poisons, while others remain relatively insoluble, but are reduced to a finely divided state and form the earthy element of the soil.

Some of the soluble substances thus formed at the base of soils are necessary plant food, while some are harmful; but what is more to the point, all are harmful if too concentrated. There is need, therefore, that enough water pass through the forming soil, and on down to the ground-water and out through the under-drainage, to carry away the excess of these products. An essential part of the best adjustment is thus seen to lie in *a proper apportionment of the amount of water which goes through the soils.* If this be not enough, the plants will suffer from saline excess; if it be too much, the plants may suffer from saline deficiency.

When evaporation from the surface is active and prolonged, waters which had previously gone down to the zone of soil-formation and taken up soluble matter, may rise again to the surface bringing the soluble matter up and leaving it at the surface on evaporation. Up to a certain point this is favorable to the plant; beyond the critical point, it begins to be harmful, as abundantly shown in the "alkaline" efflorescences of arid regions.

Besides the water that goes through the soil into the subdrainage, and that which runs off on the surface, enough must be held *at all times in the soil during the growing season* to supply the plants, and yet not enough to water-log the soil.

Here, then, are a series of possible excesses and deficiencies, between which lie the golden means which give best results. The problem of soil-management thus appears to be a problem of proper balancings and adjustments.

The key to the problem lies in due control of the water which falls on each acre. This water is an asset of great possible value. It should be the habit of every acre-owner to compute it as a possible value, saved if turned where it will do good, lost if permitted to run away, doubly lost if it carries also soil values and does destructive work below. Let us repeat the story of its productive paths. A due portion of the rainfall should go through the soil to its bottom *to promote soil-formation* there; a due portion of this should go on into the underdrainage, *carrying away harmful matter;* a due portion should go again *up to the surface carrying solutions needed by the plants;* a due portion should obviously go into the plants to nourish them; while still another portion should run off the surface, carrying away a little of the leached soil matter. There are a multitude of important details in this complex of actions, but they must be passed by; the great features are clear and imperative.

Experimental studies have shown that, on the average within our domain, *crops can use to profit all the rainfall during the growing season, and much or all of that which can be carried over from the non-growing seasons.* This greatly simplifies the complex problem, for the highest crop-values will usually be secured when the soil is made to absorb as much of the rainfall and snowfall as practicable. There are, of course, many local exceptions. In securing this maximum absorption and internal soil-work, the run-off, and hence the surface wash, will be reduced to a minimum. It has already been seen that the wash of even this inevitable minimum is likely to be still too great to keep the proper slow pace with soil-generation, when the surface has much slope. Except on very level ground and on lodgment surfaces, there need be no solicitude about a sufficient removal of the soil surface. The practical problem then lies almost wholly in retaining and passing into the soil the maximum of the precipitation. Obviously this gives the minimum of wash to foul the streams, to spread over the bottom lands, to choke the reservoirs, to waste the water-power, and to bar up the navigable rivers. *The highest solution of the problem for the tiller of the soil essentially solves the whole train of problems.*

How is this control to be effected? All the known and tried methods of preventing wash and turning the rainfall into the soil should be duly employed. It is obvious that all methods of culture and all crops that increase the granularity and porosity of the soil contribute to the end sought. Deep tilth to promote soil granulation and deep-rooting plants to form root-tubes are specific modes of great value. Artificial underdrainage by preventing water-logging and promoting granulation aids the end sought. Contour cultivation by arresting and distributing the surface wash may also assist. Alternate strips of protected and cultivated land, reservoirs for catching and distributing concentrated rainfall, and other devices, serve to limit the wash of the slopes and give the surface waters the right direction.

It is possible that some of the more radical and permanent remedies will be found by a closer study of nature's methods. Nature has been working at this complex problem of balance between soil formation, soil waste, surface slope, plant growth and stream development, for millions of years. Looking closely at her methods, we note that she uses a much larger variety of plants to cover and protect the soil than we do, and that these plants have a wider range of adaptation to the special situations where protection is needed. We may, therefore, inquire whether we should not follow this precedent farther by developing more kinds of profitable plants and by using the protective varieties more freely on slopes especially subject to wash. Forest trees are a resource of this kind and should be employed as fully as practicable, as will, no doubt, be urged with great cogency by those who discuss the problem of forestry. We also have many shrubs, vines and fruit trees, whose employment to the maximum in covering areas subject to wash is likewise urged, either alone or in conjunction with trees. We are forced to recognize, however, that for the greater part the berries and fruits which render these profitable are perishable and have limitations of preservation, transportation, market, etc. But if shrubs and vines could be evolved by modern selective methods, whose nut-meats or dry seeds should be available for food in place of the watery pulp, and which could be treated much as cereals are, and have similar wide year-round markets, there would be a larger choice of crops to grow in soils subject to wash, and we might secure soil-protection with less crop-limitation. There would then be less need to press the culture of the cereals so far as we do now, and they could be limited more largely to surfaces less subject to harmful soil-loss.

Another of nature's marked methods is the formation of plant-societies, or, from our point of view, combination-crops. No doubt there is much deleterious crowding and repressive rivalry among the natural mixtures of plants, but at the same time there seem to be associations that are mutually beneficial. No doubt man secures a great temporary advantage by isolating chosen plants and freeing them from competition, but this is clearly at some permanent disadvantage which is partially corrected by rotation, fertilizing and tilth. Can not a greater advantage be secured by a larger use of the combination method? It is clear that legumes and cereals are helpful associates in rotation and in some combinations. May not the principle be pushed much farther by the modern processes of selection and culture, so that legumes and cereals may be made more intimate companions in culture; so that, indeed, such helpful associates may replace weeds as the constant and spontaneous companions of the crops we cultivate? While kept in such subordination as to be servants of the chosen crop, may they not still aid effectively in covering and protecting the soil and thus guard against undue surface loss. Certainly much can be done by such congenial plants, used as fall, winter and spring crops, to cover the soil when specially exposed to wastage.

These and similar devices may be used to reduce the bare surfaces so much developed by present modes of cultivation, and may make it possible to cover permanently by profitable protecting crops the slopes where surface wash is most menacing.

But a critical question remains to be answered: Can such modes of soil-management and crop-selection be made to give reasonable profits? Before we can hope that the millions who till the soils will join effectively in a radical scheme of soil-conservation, it must be made to appear that the scheme will give reasonable returns at every large stage of its progress; must pay, let us say, in the long run of a lifetime. We may fairly assume that intelligent people will be guided by the total returns of a lifetime in lieu of beguilement by the ultra-quick returns of forced and wasteful cropping in total neglect of later results. It may be assumed that he who tills a farm from his twentieth to his sixtieth year will find more satisfaction in the summed profits of forty crops of increasing value, enhanced by the higher value of his land at the end, *even though the margin above cost be no greater,* than in the sum of forty crops of decreasing values with a debased land at the end. Our practical problem is, therefore, to so improve processes, to so increase intelligent management, and to so exalt the point of view, that every large step in the processes proposed shall give satisfactory returns for the labor involved. How far this is practicable just now, I must leave to those whose technical knowledge in the practical art of tillage fits them to answer; but it is clear that if such protective measures are not profitable now, they must soon become so; for, if the loss of soil proceeds at the present rate and the number of inhabitants continues to increase as now, the value of the residue of tillable land which will remain after a few centuries will so appreciate as to force extreme measures for its conservation. The pitiable struggles of certain oriental peoples to retain and cultivate the scant remnants of once ample soils is both an example and a warning. Our escape from such a dire struggle should spring from a clearer forevision, a deeper insight, greater technical skill and indefatigable industry.

Note.—Much valuable literature bearing on this and kindred subjects will be found in the numerous publications of the U. S. Department of Agriculture and the several State Agricultural Stations. Notable among these is the Farmers' Bulletin No. 20 on "Washed Soils," and a special contribution to "Soil Erosion" by W J McGee. The fundamental work on "Rocks, Weathering and Soils," by Dr. Geo. P. Merrill, of the National Museum, is also to be noted. Particularly valuable are the writings of Professor F. H. King on "Soils," "Soil Physics" and "Soil Management," and, especially for the south and west, the work on "Soils," by Professor E. W. Hilgard.

THE MISSISSIPPI RIVER PROBLEM

BY WALTER SHELDON TOWER, PH.D.
UNIVERSITY OF PENNSYLVANIA

THE project for a deep waterway from the Great Lakes to the Gulf has been dreamed about and discussed intermittently for half a century, but nothing definite ever came of it until a little over a year ago, when, from a conference held at St. Louis, there was born the permanent organization called the "Lakes to the Gulf Deep Waterways Association." That this concerted movement came at the psychological moment has been indicated by subsequent events. Last winter the Rivers and Harbors Congress in session at Washington supported the project. The president in his Memphis address heartily endorsed the enterprise; shortly afterward his annual message called attention to the need for river improvement and the question is now in the hands of congress with some definite action sure to come in the near future.

Within the last decade, this country has entered three fields of government activity, forest conservation, reclamation of arid and swamp lands and the building of the Isthmian Canal, the far-reaching results of which can scarcely be estimated at this time. The development of a ship channel through the Mississippi Valley, with feeding lines in the larger tributaries, would likewise be of such tremendous importance to the economic progress of the country that it must be ranked second to none in the list of great national policies.

A few simple statements of fact furnish striking evidence of the need for such a waterway. The drainage basin of the Mississippi system covers an area of approximately a million and a quarter square miles, or rather more than two fifths of the United States proper. This two fifths of the country is the real heart and soul of the nation's prosperity. With its development the United States has not only become independent of the rest of the world, but also has risen with tremendous strides to stand as the greatest producer of food-stuffs that the world ever has seen or ever will see. More than half the total population of the country to-day is found in the score of states bordering directly on the navigable portions of the Mississippi system. As the population increases the most rapid growth must be in these same states, until a century hence with hundreds of millions of people living between the slopes of the Alleghenies and the Rockies, there will exist in the Mississippi Valley the highest and most permanent type of civilization in the history of man. Three fourths of the world's cotton crop is raised in the United States, and the heart of the cotton belt must for all time lie in Mississippi, Louisiana and Texas. Our corn crop is three times as great as for the rest of the world combined, and, though corn is widely grown both north and south, the chief corn belt naturally centers in the Upper Mississippi and Ohio Valleys. For example, five states, Illinois, Iowa, Kansas, Nebraska and Missouri, raise over half the total for the country, or, astounding as it may seem, nearly 40 per cent. of the entire world's crop. Wheat, cattle, hogs, vast quantities of oats, hay, potatoes, lumber, coal and other mineral products come mainly from the Mississippi Valley, each one in point of quantity leading all other nations of the world, and yet no one denies that the limit of productivity is far from being reached. Out of this list, cotton, meat products and bread-stuffs make up a large part of our foreign commerce, with half the world's mileage of railroads required to get the products to the seaports. As might be expected, by far the thickest railroad net is in the Mississippi Valley, yet the roads there have found their facilities increasingly inadequate to handle the produce of the region. "Shortage of cars" has become a familiar complaint in the wheat fields of the northwest. Corn and cotton in the states along the Mississippi have been kept out of the markets because of increased rates on rail shipments. On every side the farmers have raised the cry, "Better freight facilities," but the railroads have steadily failed to meet the demand. Conditions have gone from bad to worse until now the harassed producers see that their only salvation lies in the development of the routes so bountifully supplied by nature, with coordination of rail and water facilities to prevent disastrous opposition.

It is not a case of providing merely enough to meet present needs, for the growth of this vast interior storehouse still continues with gigantic strides. Irrigation, dry farming, swamp drainage, and the exploration of the whole world to give new crop species, are opening every year areas which have heretofore produced little or nothing, while crop improvement and intelligent soil management are adding millions of bushels to the yield of the older regions. Marked by developments unparalleled in the history of the world, there seems to be no limit to the enormous capacity to produce over areas measured in tens of thousands of square miles, areas whose crops alone determine panic or prosperity for the entire nation; areas wherein lie the sinews of the greatest and most stable world power in all history. Not England, nor Russia, nor China, not any other nation or continent of the world, can equal in all its territory the unbounded natural advantages of the Mississippi Basin. Yet with each added harvest the pinch of traffic congestion and heavy transportation charges are felt by an increasing proportion of the population, and as long as such conditions continue the full economic development of the region must be seriously hampered.

The logical solution of all the difficulties lies clearly enough in the utilization of the great arterial system of waterways afforded by the Mississippi and its tributaries. The time was when these rivers were the life currents of the region. In the days when river craft plied the Mississippi, Missouri and Ohio are found the conditions which gave birth to, and stimulated the growth of, St. Louis, Cincinnati, Louisville, Memphis, St. Joseph, Kansas City, Omaha and a host of other river cities of all sizes. To-day these cities are railroad centers, but by that very fact of having ready-made terminals the development of the water route takes on added value. Take, for example, St. Paul and Minneapolis, at the head of navigation on the Upper Mississippi, the greatest flour-milling centers in the world, shippers of hundreds of thousands of tons for both home and foreign markets and at the same time the logical railroad centers for a large section of our own northwest and Canada. Kansas City, almost in the geographical center of the country and undoubtedly destined to become one of the greatest inland cities of the continent, with St. Joseph, Omaha and Sioux City, all lie in the range of former navigation on the Missouri and stand as important shipping centers for the great corn, wheat and cattle trade of the country back of them. The vast quantities of products handled at these places are mainly bulky goods which do not suffer seriously from relatively slow transit, but which do need most urgently the means of getting to market at the lowest possible transportation charge. No better illustration of the advantage of shipment by water can be found than that afforded by the coal trade from Pittsburg to points on the Mississippi. Coal can be sent from Pittsburg to New Orleans by river, 2,000 miles, for about 75 cents a ton, while the rate by rail to Memphis, 807 miles, is over $3 per ton. On the basis of the charge per ton per mile, the latter rate is about ten times as heavy as the former, a fact which becomes strikingly significant when it is considered that a saving of a single mill per ton mile means $1,000 saved on every shipment of 1,000 tons going 1,000 miles. A similar saving on a comparatively small part of the annual cereal crop alone in those states bordering the Mississippi system would very soon reach a total surprisingly close to the entire cost of improving the navigation.

A waterway with a depth of fourteen feet from New Orleans to Chicago, with channels of less depth in the Ohio and Missouri, would almost unquestionably solve the problem of traffic congestion and high freight rates for a great area of the productive west. It would be a movement directly in line with the policies of various European nations, where far less valuable waterways in thickly settled districts have been utilized most profitably. It is an enterprise which the United States must inevitably undertake sooner or later as the density of population increases throughout the Mississippi Valley. Railroads, thoroughly equipped, yet inadequate to meet the conditions of the present time, will be relatively less able to cope with the rapidly growing demands for transportation facilities in the future. Already in the more densely populated portions of the country waterways once abandoned are being rehabilitated. The country can not long afford to ignore the possibilities presented by the development of the greatest natural highway in the world—the Mississippi and its navigable tributaries. It can not be denied that the improvement of our greatest inland waterways will be followed by vastly more important industrial and commercial advantages than can ever result from the opening of the Panama Canal. These advantages would be not to the people of the Mississippi Valley alone, but to the people of every county and corner of the Union through their dependence on the products of this region.

The project, however, is not at all simple—it is an undertaking fraught with problems which, unless met rightly at the start, must inevitably defeat the entire purpose of improvement. Like all big rivers, the Mississippi and its tributaries have bad habits, the worst of which are devastating floods, followed by very low stages of water at other times; rapid changes in the course through sapping of the banks; and constant shifting of the channel, often over night, on account of the formation of sand bars. In these respects our rivers are not necessarily any worse than others, in fact, they are not so bad as many of the great rivers of the world, but the correction of these habits becomes an unavoidable and serious question when efficient improvement for navigation is undertaken. The question of river control and improvement is most intimately connected with forestry, farming, mining and other industries, since they in many cases largely determine the particular problems with which man must deal. In the Ohio the overwhelming spring floods and low water stages of summer are the chief difficulties, with slack water dams doing much to remedy the latter condition and make navigation possible at all times. The sand-bar evil in the Missouri is so great and so perplexing that it completely overshadows the question of flood control and sapping of banks, which are in themselves of no slight importance. Along the lower Mississippi from St. Louis to the Gulf all three problems urgently demand attention, since this portion of the river represents the trunk line of the entire deep waterways system; and it is just here that the physical conditions surrounding the river make correction or control the most difficult.

From St. Louis southward, the river course follows a broad alluvial plain, which gradually increases in width to about 100 miles near the Gulf. This broad river flat is composed of a soft, highly-productive soil, fine-grained and of indefinite depth, in which the river has developed such a tortuous course that while the air-line distance from Cairo to the Gulf is about six hundred miles, the journey by water is twice as long. On every one of the many turns and bends throughout the whole twelve hundred miles the river is constantly undermining and wearing away the outer bank of the channel in just the same way as the outer rail of a curve on a railroad is worn rapidly and must soon be replaced. The fine-grained, loose character of the soil greatly facilitates the undermining action, especially during the irresistible rush of flood waters.

This habit of eating away its banks is perhaps the worst which can be charged against the lower Mississippi, and presents one of the most serious problems in the whole question of control. Needless to say the unceasing changing of the course is vitally important to the plantation owner, who sees his fertile land steadily vanishing, often at the rate of 300, 400 or more feet a year along his entire water front. It is still more important to the towns and shipping points located along the river. New Orleans is the only big city located directly on the river flat, and, fortunately for the city, it is at a place where the river's course is now comparatively straight. Other cities, like Memphis, Vicksburg and Natchez, are located on the high bluff where the river swings close against the eastern side of its valley. These latter towns have secured immunity from floods, but even simple changes in the channel would deprive them completely of their water fronts and strike fatal blows at their prosperity.

Even the present extent of the river traffic demands that there shall be more or less villages directly along the river and steamboat landings at various points, but every one of these places enjoys only a temporary existence. Since the river current hugs close along the outer side of every curve in its course, it follows that the deepest water, and hence the main channel, also lies near the outer bank. The natural result is that all steamboat landings and all important shipping points must be located on the outer banks of curves, as is found to be the case all along the river. The difficulty which lies therein is obvious enough, for with rapid undermining of the outer bank of all bends, the river is always tending to destroy the water front of every place so situated. The history of the landings below Cairo shows that practically every one of them has been driven back before the advancing river at the rate of 100 to 150 feet a year for the last quarter of a century.

That this condition is felt on a larger scale than by mere landings is shown by the case of Greenville, Mississippi. This city of nearly 8,000 people, the largest river port between Vicksburg and Memphis, is the flourishing commercial center for an important part of the lower valley, yet imminent ruin is even now staring it in the face. Greenville stands on the outer bank of a great curve in the river with three other curves up-stream from it. Narrow necks of land separate the different curves, and these necks are rapidly disappearing as the banks cave in. Twenty-five years ago at the curve farthest up-stream from the city the neck was over 4,000 feet wide, five years ago it was less than half that width and was caving badly. The neck below the city is only half a mile wide and is also yielding rapidly to the attacks of the river. Greenville is confronted with these alternatives: If the neck below the city is cut through first by continued sapping, the city will be left high and dry, five miles from the river and its reason for existing will be gone. If, on the contrary, the neck above the city is the first to succumb, the resulting changes in the channel will cause most vigorous scouring of the bank exactly where Greenville stands and it will be speedily swept away. The levee now stands where the main street once ran and, despite every effort to stop it, the town has been forced to play leap frog over itself to keep away from the advancing river. Through the expenditure of a million dollars in protective devices the crisis has been delayed, yet the city is doomed eventually, and the money spent in its protection must be regarded as wasted.

St. Joseph, Missouri, with a population exceeding 100,000, and one of the most important centers of the west, faces a somewhat similar fate from the Missouri river. Opposite the city the stream swings around a great bend, St. Joseph being located on the bluff above the river bottoms. Some smaller villages on the flat have already been swallowed up in the stream, and, at its present rate, the current will soon cut its way through the narrow neck which lies a few miles west of the city, severing the Grand Island railroad, rendering the big steel bridges at St. Joseph practically useless, making new bridges over the new channel necessary, cutting off the intake of the water supply, and leaving the city without any outlet for its sewer system. Here, again, somewhat over a million dollars has been spent in river work above and below the city, but the banks have continued to cave, and St. Joseph is facing the prospect of being left higher and dryer than Greenville. From the standpoint of transportation by water, however, the loss of the river front at St. Joseph would not now be a serious calamity, since the Missouri route is at present rendered quite useless by the excessive formation of sand bars.

Both the federal government and the Chicago and Alton railroad have spent large sums in an attempt to control the Missouri at Glasgow. Kaskaskia, the one-time capital of Illinois, has been wiped out of existence by the changing current of the Mississippi, while the prospect of a cut-off at Cowpen Bend, above Natchez, indicates that the harbor of that city will be destroyel by the deposition of large quantities of sand along the entire water front. Striking as these individual cases may be in themselves, the question of this cutting away of the banks, accompanied by deposition of sand in other places, takes on far greater significance as soon as costly improvements are suggested. It is undeniable that what is happening along the river to-day is a true sample of what the river may be expected to do every day as long as the existing conditions prevail. A fourteen-foot channel presupposes important movements of goods from many points along the river. Large shipments can not be handled readily or economically without expensive modern terminal facilities along the river front, but the building of such terminal facilities can not be expected as long as they are threatened with the same fates as now confront Greenville, Natchez and St. Joseph.

The flood evil, the second great problem to be met in the control and improvement of the Mississippi system, has been fresh in the minds of every one since the disastrous spring of 1903, when the loss of property amounted to fifty or sixty million dollars. The flood problem applies not only to the main Mississippi itself, but perhaps even more vitally to its chief tributaries, the Missouri and Ohio, which must be regarded as the main feeders to any proposed improvement. The total loss from a few historic floods in these streams has been tremendous. In 1881 and 1882 the floods of the Ohio and lower Mississippi caused a loss of $15,000,000. In 1884 the Ohio Valley alone suffered to the extent of $10,000,000. An area twice the size of New Jersey was laid waste along the lower Mississippi in the spring of 1897 with losses again reckoned in tens of millions of dollars. The unprecedented ravages of the Missouri came in May and June of 1903, and finally this last year saw damage to an extent estimated at not less than $100,000,000 in the Ohio Valley. In the last quarter of a century, therefore, the plain money loss from a single half-dozen floods approaches a quarter of a billion dollars, while the sum total from all floods must be acknowledged to equal many times over the entire cost of the most effective and permanent means of protection.

The principal cause of the floods in the Mississippi is heavy or prolonged rains at certain seasons of the year, a primal cause, which lies beyond the power of man to control, but which has been greatly aided in its effects by wide spread deforestation about the head waters. Flood conditions vary widely in the different tributaries. The Missouri has the largest drainage basin of any of the tributaries, about 540,000 square miles, but the average rainfall over the region is small, unusually heavy and long-continued rains are less frequent, and, because of porous soils and excessive evaporation, only a small part of the rainfall passes off in surface drainage. As a result of these conditions, the Missouri supplies only about one seventh the total discharge of the Mississippi, and is, on the whole, as regards floods, the least important of the large tributaries. The upper Mississippi, with a drainage area only a third as large as that of the Missouri, turns in about one fifth the total volume of the main stream, while the Ohio, draining approximately 200,000 square miles, sends down a third of all the water discharged by the Mississippi. These three rivers, therefore, yield over 60 per cent. of the gross volume, the remainder being divided between the White, Arkansas, St. Francis, Yazoo and Red rivers, which join the main stream too near the mouth to be important factors in the production of severe floods.

The Ohio is, on the whole, much the worst flood offender, partly because of its normally greater volume, and partly because of the conditions existing in the region it drains. The major portion of the areas drained by the Missouri and the upper Mississippi are distinctly less rugged than the Ohio basin, and over both areas the heaviest rainfall, coming in May and June, arrives at a season when the soil can take a large percentage of it. The largest tributaries of the Ohio, on the contrary, in etching their valleys in the surface of the Allegheny plateau, have produced the steepest and most rugged parts of the whole Appalachian region. Here the heaviest rainfall comes in January, February and March. Add to these factors the frequent complications of melting snow and frozen ground, which sheds water like a house roof, a district largely deforested, and the enormous destruction by sudden rising of the Ohio is explained. It is truly fortunate that by the provisions of nature the three rivers, the Ohio, the Mississippi and the Missouri, have never been known, and probably never will be known, to be in extreme flood at the same time. Such an unhappy coincidence of high stages, if it came about, would quite certainly mean total obliteration for everything in the lower valley.

The flood evil is in a large way the underlying cause of most of the trouble in the Mississippi. At time of flood, the erosive power of the river is increased a hundredfold, caving of the banks is often excessive, levees situated rods from the channel before the flood and apparently safe are undermined, and the narrowing of necks between bends is greatly accelerated or quickly accomplished. Much of the damage from floods must be laid to the cavings of banks by which landings are destroyed and whole plantations are soon swept away, while through breaks in the undermined levees the raging waters sweep over the surrounding country. This spread of the flood is fostered by the fact that the river channel lies above the surrounding bottom lands. To the naked eye the region appears absolutely level, but from the river the broad plain slopes away at a rate varying from four to thirteen feet per mile. Once outside its channel, therefore, the water finds a natural course down hill into every part of the back country, carrying destruction wherever it goes. Unfortunately, this character of the river can not be altered; on the contrary, the more the river is confined between artificial levees and restricted in the area over which it is free to spread, the greater will be the devastation whenever a flood does occcur, so that with the extension of the levee system the occurrence of floods becomes an increasingly serious problem. The recognition of this fact can not be urged too strongly, for until the flood waters are under absolute control, the construction of a deep channel, no matter whether it be in the river itself or in the form of a canal along the stream, must be done in the face of constant danger of having the entire system crippled and large portions destroyed whenever overflow takes place.

Again, when the river is in flood, as it is to a certain degree every year, it is carrying along the greatest amount of sediment, much of which represents the most fertile part of the soil. The total amount so carried is almost beyond conception, but to carry it by freight train would require 500 trains for every working-day in the year, each train consisting of fifty cars with a capacity of fifty tons. Besides this tremendous quantity poured out into the Gulf every year, other incalculable masses are deposited as bars all along the course, and as the water falls to its normal level these bars are a constant menace to every form of navigation. The presence of these obstructions and their rapid shifting from day to day has always been one of the most serious handicaps to river transportation. In fact, the abandonment of navigation on the Missouri may be laid entirely to the utter inability to cope with the shifting sands. Deforestation, cultivation of the land especially, and mining operations, are vitally important in the question of soil washing, surface erosion and the amount of sediment in the streams.

The project for a deep waterway for commercial purposes, therefore, is confronted with these serious problems which must be solved before the government can afford to spend one or two hundred million dollars in river improvement. Some system of control must be devised to insure to water fronts and terminal facilities a reasonable degree of permanency through protection against erosion of the banks. There must be some way of checking disastrous floods which would in a single season, and perhaps year after year, destroy improvements costing millions of dollars—as the experience of some of the eastern canalized rivers indicates. The prevention of low-water stages is no less important, since marked variations in the water level make it difficult to establish the necessary terminal facilities. Finally, the formation of sand bars must be stopped, otherwise it means stupendous, unending and probably ineffective, dredging operations in an attempt to keep the channel open.

If the Missouri could be removed from the list of tributaries by giving it a separate mouth, the sand-bar problem would no longer exist, since that stream contributes over 60 per cent. of the total brought into the Mississippi. Reducing the load by 60 per cent. would certainly mean that the Mississippi could then keep its own channel clear. But the idea of providing a separate course for the Missouri from St. Louis to the Gulf is too daring even to be suggested. Moreover, it would remove from the immediate benefit of the deep waterways project those important communities which hope for renewed navigation on the Missouri.

If the entire lower Mississippi were given a new course free from sharp bends, as could be done readily by cutting through the successive necks, the sapping and caving of banks would cease and the distance from St. Louis to New Orleans would be lessened nearly by half. That this plan is entirely feasible is amply demonstrated by the success of the Germans in correcting and straightening the Rhine. The Rhine, if possible, presented a more difficult problem than does the Mississippi, but the German engineers recognized the fact that where sharp bends exist it is impossible to prevent entirely undermining and caving of the banks. Acting on this principle, it was decided to give the river a practically new course, less winding than the former, and in which future control is insured. Unfortunately, this procedure applied to the Mississippi would not be an adequate remedy for the floods, nor would it effectively prevent the formation of sand bars. It is unquestioned, however, that the flood stages would run off more rapidly and a greater amount of sand would be scoured from the channel, since in a shortened course the river would have a steeper descent and consequently a more rapid flow with increased carrying power. The corrected course undeniably has much to recommend it, aside from the mere facts of feasibility and a shorter route.

If the high-water stages of floods could be prevented and the flow of the river controlled, the practical solution of the question would be at hand, for the major part of the sediment is washed into the streams incident to the flood time, and the excessive flood volume causes most of the caving of banks. For a good many years the federal government has been at work on the Mississippi, building levees to control or prevent floods, placing revetments along the banks to check the caving action, and operating powerful sand pumps to remove the shifting bars. It is estimated that in the last forty years the government has spent all of $225,000,000 on the Mississippi and its more important tributaries, not a single dollar of which has gone toward permanent improvement, except in the case of the jetties at the mouth, the slack water dams on the Ohio and the removal of rock ledges at a few points. Fifty million dollars of the total amount has gone into the construction of some 1,400 miles of levees and revetments along the lower course, but before the national government undertook the task of control, the states of Mississippi, Louisiana and Arkansas had already spent not less than $40,000,000 toward the same end. Enough similar work has been done at one time or another by private individuals, so that, first and last, the levee-revetment system to date represents an outlay of fully $100,000,000. Yet not one cent has been devoted to the control of the excessive floods which come almost every year in some of the tributaries, simply because the levee method can not be applied there. It must be admitted that the levee system affords fairly efficient protection from ordinary floods, in so far as damage from overflow in the lower valley is concerned, but its desirability is seriously impaired by the fact that the levees must be constantly replaced. Just as long as the river is allowed to swing against its banks the soft alluvial soil will continue to cave in; levees originally built back from the channel are eventually undermined, rendered useless, and then in cases of high water stages, unless a second line of levees exists, the entire region is open to devastation. Until the sapping action of the river is under control there can be no such thing as a system of levees built once for all. Even the most optimistic advocates of this plan do not claim more than twenty to thirty years for the life of any levee.

It is undeniable that the army engineers in charge of the work have accomplished much in saving large areas from annual inundation, but they have not to any extent permanently improved the river as a highway of commerce. Furthermore, they have signally failed in the attempts to stop erosion of the banks, for past experience shows that no style of revetment yet devised will offer more than partial or brief protection from that action. In fifteen years some landings have been forced back more than a mile, and at important points where careful revetting has been done the retreat is said to have exceeded 1,000 feet. The levee-revetment system as now practised may be the simplest way of protecting agricultural interests on the river flats, but it is certainly not the most economical in the end, nor does it in any way afford even a temporary solution of the great problems confronting navigation and river commerce. The heavy expense of maintenance must go on without end until the sum total of expenditure will aggregate vastly more than the cost of the proper, permanent remedy. The most serious of all the shortcomings charged against present methods, however, is that they do not strike at the root of the evils. The place to control floods is where they originate, in the tributaries, and thus protect both tributary and main valleys; as well try to fight fires by blowing away the smoke as to control the floods by levees along the lower course. To improve the river to the extent of a fourteen-foot channel to St. Louis would be a foolish waste of money as long as the levee-revetment system is the chief method of control.

Various other methods of control have been suggested from time to time, but most of them do not appear feasible or to offer the desired results. The rearrangement of tributaries, either by diversion or by addition, has been advocated, since the addition of tributaries to the Po very materially lessened the flood evil, the increased volume and velocity having caused a marked deepening and widening of the channel. In the Mississippi case, however, there are no important streams which could be added, and the only possible source of increased volume is by giving the Great Lakes an artificial outlet by way of the Illinois River. A certain amount of diversion or rearrangement of tributaries would be possible, though not very practicable, as in getting rid of the load of sediment from the Missouri, or in turning the Tennessee through the Big Hatchie River to reduce the Ohio floods. But in all of these radical schemes the possible benefits to be derived are far outweighed by the inevitable difficulties and disadvantages. It is unquestioned that the tributary system must remain as it is now.

The construction of artificial outlet channels to take off the excess volumes which produce floods has been suggested many times, and it seems likely that if constructed in sufficient numbers they would prove effective. There would, however, always be great difficulty in keeping the outlets sufficiently free from sand so that their usefulness should remain unimpaired. A second and more serious objection to the outlet scheme is that in the lower valley, where the flood control is most difficult and the flood damage most wide-spread, the outlets would have to be provided by turning the water over the low-lying bottom lands. Outlet reservoirs could not be maintained because of the sand and mud with which they would be speedily filled. Under such conditions, therefore, the outlet plan clearly defeats one of the chief objects of flood control—the protection of rich plantations covering thousands of square miles on the river bottoms.

The solution by building a series of reservoirs in the head-waters of the chief tributaries appears to be the cheapest and most certain remedy for all these difficulties. By the construction of reservoirs the excess of water which produces flood stages could be impounded and held up with these important results: excessive and destructive high-water stages could not occur, while, on the other hand, by regulating the discharge from the reservoirs, a more even flow of water could be maintained at all times, eliminating to a large degree the losses from diminished water supply, reduced power and fouling of streams incident to the low stages of late summer and early autumn. As soon as the irresistible rush of flood waters is stopped the sapping and caving of banks will be reduced to a minimum, with the efficiency of revetments increased many fold; finally, cutting down the flood volumes means a great diminution of the amount of sediment carried, and a marked alleviation of the sand-bar evil. The reservoirs would, moreover, eliminate floods from the whole system, not merely from the lower course. The prevention of the annual flood damage in the Ohio would in itself be worth the entire cost of the reservoirs, yet until the work of control is carried to the headwaters no relief can be secured for that populous valley.

The solution by head-water reservoirs, of all proposed plans, has probably provoked the most discussion—on the one side, those who regard it as impossible, or, at least, highly impracticable; on the other side, those who consider that it is not only feasible but at once the only proper remedy. It is admitted by every one that the topography of the country about the head-waters of the Mississippi system is especially well adapted to the construction of retention dams and reservoirs. The arguments advanced against this plan, though admitting this condition of favorable topography, maintain that sufficiently large reservoirs could not be constructed and made safe or, in other words, they would, through danger of bursting, be a constant menace to the whole valley below the retaining dam. Again it is argued that if this plan were adopted, the building of reservoirs would have to be done on an enormous scale, since destructive floods often result from local conditions, such as a swollen tributary superimposed on an already swollen river. This necessity for a widely extended system of reservoirs, it is further claimed, would involve such tremendous expense as to make the adoption of the plan impossible. Most of these supposed objections are still based on a report made to congress nearly fifty years ago, and, whether good or bad arguments then, there is no question that they do not apply now.

It is flying in the face of cold facts to contend any longer that reservoirs to retain the flood waters can not be built, or not without danger to the entire valley below. The Ohio floods of 1907, the most disastrous for more than two decades, were due to an excess of water estimated at 23,000,000,000 cubic feet. To hold every drop of that excess discharge would have required a reservoir only a little more than half as big as the Pathfinder irrigation storage reservoir on the North Platte River in Wyoming, or one third of the size of the reservoir in the Salt River project in Arizona. The Engle dam on the Rio Grande, a hundred miles north of El Paso, Texas, will impound about 120,000,000,000 cubic feet of water, equal to one sixtieth of the total annual discharge of the entire Mississippi system, or more than five times the quantity of water causing the most destructive Ohio flood in a score of years. These reservoirs are being built by the government at a cost of about $4,000,000 for the Pathfinder dam, $5,300,000 for the Salt River project and $7,200,000 for the Rio Grande reservoir. Furthermore, it is expressly stated by the Reclamation Service that the Wyoming reservoir and the Engle dam will absolutely control the worst floods which the North Platte and the Rio Grande have ever known, the latter of these streams having been a notorious offender in flood damage. The mere fact of being able to retain the flood waters in impounding reservoirs can no longer be denied, nor can the claim of danger from breaking dams be now advanced as a valid argument against this system. This government is most assuredly not spending millions in reclamation projects and encouraging thousands of people to take up irrigated lands if there is any remote likelihood of having homes, property and lives wiped out in floods from bursting reservoirs.

Granting, then, that the reservoirs are feasible, there still remains the question of expense in constructing the number necessary to place one or more in each of the most important tributaries. Estimate the expense most generously, letting each one cost a third more than the Engle dam above El Paso, and the total figure then is less than what has already been spent on the Mississippi system. But there is another important factor to be considered—the tremendous possibilities which lie in the development of water power from each reservoir. The question of future motive power for industrial purposes, as the coal supply decreases, is a problem which must soon be met in this country, and probably will be solved by the use of water power either directly or through electricity. In fact, even now, water rights are being rapidly acquired and developed on every hand, as the advance guard of the change that is to come. A sample of what a storage reservoir will do can be seen in the case of the comparatively small irrigation project at Minidoka, Idaho, which will develop about 30,000 horse power per year. Renting this power at the very low figure of $10 per horse power per year would pay for the entire Minidoka project, reservoir, irrigation-canals, gates and all, in six years. The amount of power generated by the Mississippi system is variously estimated high and low, with 60,000,000 horse power per year as an intermediate figure. Much of this amount is not directly available, but granting on a conservative basis that a series of impounding reservoirs would develop immediately 2 per cent. of that amount, there would be 1,200,000 horse power to be turned into electricity and distributed to factories. A purely nominal rental would be ample enough to repay in two or three decades the entire original expense of the system, besides a good income on the investment. The reservoir system, however, must be intimately associated with forest conservation as a vital factor in regulating surface drainage and in checking the amount of soil erosion which supplies sediment to the river.

The proper building of reservoirs in the headwaters, therefore, offers what no other plan can possibly offer: it promises effective regulation of river stages and water supply for all time to come, removing entirely the liability of destructive floods, checking the erosion of banks and preventing much of the formation and shifting of sand bars and the pollution of water which the presence of sediment means. At the same time it provides a way of actually paying for itself in short order, aside from all idea of the savings to shippers and river interests in general which would be in excess of the cost. The importance of this latter consideration is emphasized best by a brief comparison with the system now being followed. The levee-revetment system, as mapped out, calls for an expenditure of $60,000,000 for its completion. From the engineers themselves comes the statement that the average life of a levee is not over twenty years, which means this and no more: in two-score years, at the most liberal estimate, the present system, completed, will have disappeared entirely and a new series of levees constructed at the cost of another $60,000,000 will have taken its place, with conditions then no better than they are now. Considered solely on their own merits from the standpoint of control afforded, the present system has nothing, and the reservoir plan has everything, to recommend it.

In order to bring the river route to its highest possible degree of efficiency, it would be necessary to combine the reservoir system with a straightened course for the lower river, by which combination every evil would be removed and absolute control for all time would be insured. The reservoirs would make it possible to regulate the flow of the streams, preventing both floods and very low water, and at the same time, through developed horse power, pay for the improvements. The corrected or straightened course would shorten the route and effectively put an end to caving of the banks with all the difficulties arising from it at present. Together the reservoirs, with the necessary forest conservation and corrected course, would remove the sand bar problem—the one greatly lessening the actual amount of sand carried into the river, the other giving the current increased power to sweep its own channel clean.

It is undeniable that this plan calls for a large expenditure for its completion, but in the long run so does the levee-revetment system, without anything tangible to show for the outlay in the end. The whole question narrows itself down to a single issue: whether it is not better policy to do the right thing at the start, even if it require great initial outlay, rather than follow a plan which means the reconstruction of part of the so-called improvements every decade for centuries, with the region concerned always chafing under the handicap of a mediocre, inadequate waterway and suffering heavy annual losses from uncontrollable floods. The waste of money on levees and revetments ought to cease once for all. Let the federal government authorize the completion of the entire reservoir system with a straightened course for the lower river, and loose the bonds which every year are drawn tighter over this heart of our nation.

THE HIGH SCHOOL COURSE[1]

By President DAVID STARR JORDAN
STANFORD UNIVERSITY

IT has been lately said by an honored teacher that the weakest part in our educational system is the high school. It has less unity in theory and less definiteness in practise than any other, and those who have charge of its administration are less sure that they are doing the right thing, than is the case with other types of schools. "As a forcing house between grammar school and college," says a recent writer, "the high school hasn't time to do anything very well." Hence it may be well to try to do fewer things, thus saving time to do some things better.

If we were to start at the beginning of education we should change a good many things. Especially should we distinguish between the college and the university in making the former the stepping-stone to the latter. But accepting our colleges and universities as they are, at the same time discarding the results of tradition and of half-hearted experiment, what should the high school do? By high school we mean the instruction in the public school for four years of school life from the age of 13 or 14 to that of 17 or 18, resting on the primary and grammar school on the one hand and presumably leading to the college on the other—in most cases the last of the years in which a student lives at home and goes to school.

The high school as thus defined has these duties clearly indicated: to give a rounded development of physical and mental powers, so that no line of talent shall perish by default; it should indicate and emphasize that form of ability which will count for most in the conduct of life and it should do its foundation work with such thoroughness that the higher education may be built upon it with the certainty that the attainments shall be solid so far as they go. This is all that the colleges and universities have the right to ask, and for them to specify certain classes of subjects regardless of the real interest of the secondary schools and their pupils is a species of impertinence which only tradition justifies. To demand thoroughness of secondary instruction and to enforce this demand in any practicable way is the duty of the college, but the question of what the high schools shall teach is a question for these schools to decide for themselves. In general, the high-school

[1] Address before the California State Teachers' Association, Santa Cruz, 1907.

graduate who has a training worth while in the conduct of life is also well fitted to enter college for further training. In general, too, the high school must consider its individual students. A well-rounded training for one is a very lop-sided discipline for another, and the development of special interests must not be overlooked. For these reasons a considerable range of choice is necessary in a good high school. This does not, however, imply an elective system such as the colleges have found necessary. In an ideal high school system the election should be mainly in the hands of the teachers. But at the same time the wise teacher makes sure that the student maintains a continuous interest in something. The lack of such sustained interest is the main reason why most of the boys drop out of the high school to get where they will be doing something dealing with things, not words.

It is clear that even yet with all the advances or encroachments the sciences have made, the study of words still fills too large a part in our secondary schools. The traditional college education was a training in words. It is easier and cheaper to teach language than anything else. The average child learns words by rote, while other subjects demand a more complex method, and the tendency is to fill the child with words regardless of the dyspepsia and disgust the abnormal diet may produce.

In my judgment, with the average student and especially the average young man, some study of natural science ought to go with every year in the school. The child is surrounded by a world of actualities, each producing a definite effect on his senses. In an out-of-door world, he recognizes that external things are real. He knows that the sun rises in the east, and he soon learns the various phases of woodcraft and fieldcraft—how to comport himself in the presence of realities. The constancy in these relations gives to him a kind of moral training, and the knowledge he obtains he wins at first hand. It is acquired in terms of his own experience and in such terms all real and helpful knowledge must always be stated.

In our cities we can not replace the training of the farm, the knowledge of the woods and hills, but we can continue to give in some degree, the essential part of it—contact with realities and extension of knowledge in terms of experience. This is through real contact with animals, plants, rocks, chemical compounds and physical instruments, and a well-conducted scientific laboratory has the same value as out-of-doors experience, with the great addition that it can be made systematic and therefore effective for power. The value of genuine nature study, study of science in out-of-door laboratories is of the very highest order. Not so the imitation nature-study, the study of sentimentalisms about nature, of nature words smothered in painted adjectives, now popular in some quarters. Of still less value are the nature books written as potboilers by men who would turn out dime novels or problem plays just as cheerfully if the literary current set in that direction. The student of realities in nature and the "nature-fakir" are not on speaking terms with each other.

Once the students cuts entirely loose from real objects, and spends his days among diacritical marks, irregular conjugations and distinctions without difference, his orientation is lost. He loses the distinction between what is inherently true and what is true by agreement among men. He does not go far enough to touch bottom again in the real science of philology. And the average American boy quits the high school in disgust because he can not interpret its work in terms of life—he can not see how its work is related to the world of things as they are.

As to the relative value of the sciences, that is a minor question. Those sciences are best which give largest play for observation and judgment. Those sciences are best which can be taught best, with most accuracy and most enthusiasm. In general, it is better to teach one science well than two imperfectly, and the reason for teaching any science is its helpfulness to the mind, not the fact that there may be money in knowing it. But to have any value at all the science we teach must deal with realities, not book-science. "If you study nature in books, when you go out of doors you can not find her."

And this, too, is a reason why manual training of some sort ought to form some part of every well-balanced school course. Training of the hand is really training of the brain. This is a motor world we live in—a world in which men do things. We of America are preeminently a motor people. We do things. What can I do with it is the first interest of every child. And to learn to do things with the hand is of greater value as mental training than the disentanglement of phrases, or the memorizing of lists of verbal irregularities. The development of manual training of some sort for all boys and girls will represent the greatest immediate forward step in secondary education. But the purpose of this training must be intellectual, not to teach a trade, and only secondarily to fit for the engineering courses of the universities.

As the third of the three most important duties of the high school, I would place the mastery of English. The student ought to learn how to write good English—clear, accurate and straightforward. He should read enough good English to know it when it is written. He should study poetry enough to know what it is about, and if he is to do any memorizing, there is nothing that enriches the mind so much as the memory of good verse. I do not know how good English can be taught. Most of the students who use it seem to have grown up in it rather than to have learned it in the schools. But it is the most important tool of every man who possesses it. It is wanted in every profession in every walk of life. The high-school course of every man who acquires it must be judged successful and no pains should be spared to emhpasize its importance. How to give this power is another question. Probably the real teacher of English, like the poet—which indeed he must be—is born, not made.

The rest of the high-school course has a minor claim on our attention. Algebra and geometry have a high practical as well as definite intellectual value. These constitute, moreover, the only door to the profession of engineering. History may be learned in the high school, but its significance is mostly seen later. The practical demands of intelligent citizenship seem to call for modern history, elementary economics and civil government as high-school subjects. Besides, those who do not go to college will read no history they do not begin in the high school. The languages, ancient and modern, have a high value to those who can master and use them, for every new language opens to a man a new world and the influences of a new civilization. Most high-school students get very little from any of them, and the one intellectually most important—the Greek—is practically excluded from our secondary schools as being of least practical value. Without in the least underrating the value of Latin to "roman-minded men," who make a manly use of it, there is no doubt that the average American high school boy gets less out of Latin than out of any other subject in the curriculum. We may regret this, but we must face it as a fact. For the rest, drawing ought to have a place in the course if only for its value as an aid to observation. "A pencil is one of the best of eyes," as Agassiz used to say, and drawing is one of the means of expressing observation in terms of action.

In brief, the American high school ought to limit the range of its activities so as not to do too much at the expense of thoroughness. It ought to broaden its range so as to give to each boy or girl what is individually best, and it ought to keep in touch throughout with realities, with the power of doing things, and it ought to cherish as its choicest art, the cultivation of the power of clear, accurate and original expression in the greatest of all languages, which is our own.

COUNT RUMFORD

BY JOHN CANDEE DEAN
INDIANAPOLIS, IND.

THE annals of history do not record many geniuses who, with so little effort, and in so short a period of time, attained the high position occupied by Benjamin Thompson. In England he became colonel in the army, under secretary of state, knight, fellow of the Royal Society, founder of the Royal Institution. In Bavaria, minister of war, major general, count of the Holy Roman Empire; counselor of state, chief of state. In France, member of the Institute of France and lecturer at the Academy of Sciences.

Thompson was born on a farm at Woburn, Mass., in 1753. His father died when he was an infant, and his mother, having but a narrow income, took him from school before he was thirteen years of age and apprenticed him to a merchant at Salem. His thirst for knowledge was even then insatiable, and he found it impossible to apply himself to anything except his favorite subjects of study.

His scientific work began at Salem, where his zeal for experimenting nearly ended his career. Having undertaken to prepare some fireworks for celebrating the repeal of the Stamp Act, the ingredients of a mortar exploded, burning his face so seriously that it was thought that his eyesight had been destroyed, but in a few weeks he recovered.

The impending American revolution put a stop to his master's trade, and he thereupon left Salem for Boston where he continued his studies, to which he added medicine, anatomy, French fencing and other accomplishments, meantime supplying himself with necessary funds by teaching school in adjoining New England towns. He allowed himself but seven hours' sleep, the remainder of the twenty-four hours being devoted systematically to reading, study, experiments and exercise.

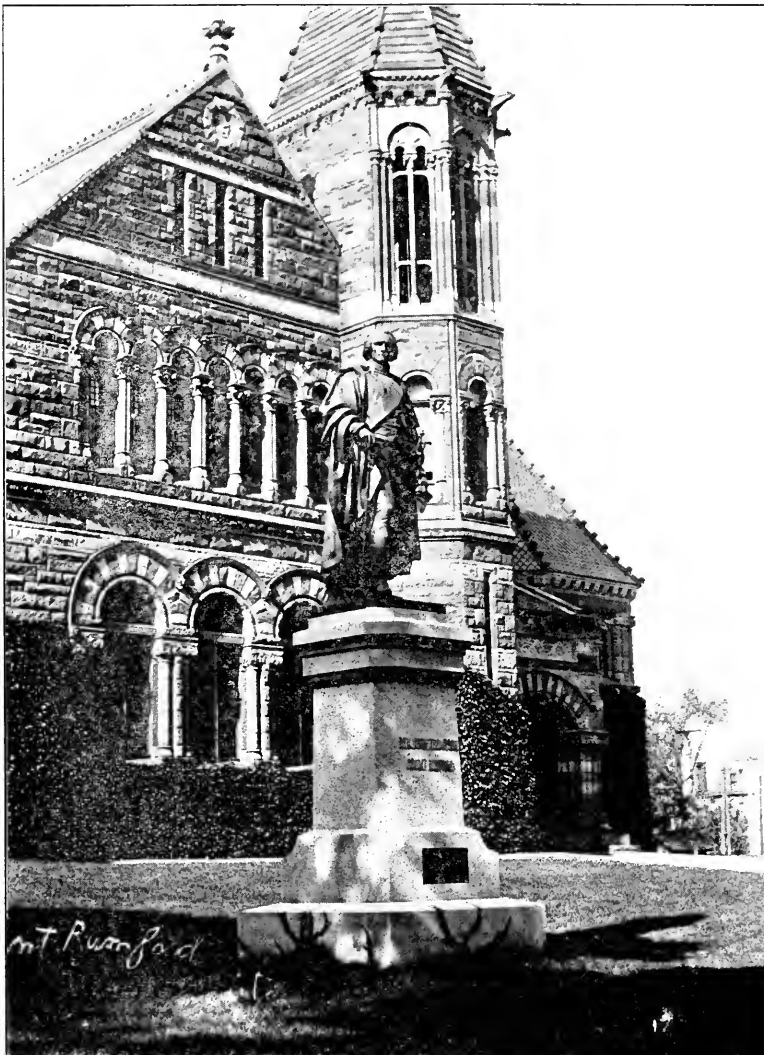
The American revolutionary period was prolific of great men. Washington, Franklin, Jefferson and Thompson were produced from a population of less than three millions. It is doubtful whether the vast population of the western hemisphere has since produced one man to rank with these four gifted men.

When nineteen years of age Thompson moved to Concord, New Hampshire, where he continued his profession of teaching. Here he met Mrs. Rolf, a young, attractive and wealthy widow to whom he was soon married. Among the prominent people whose esteem he won was Governor Wentworth, who made him Major of the Second Provincial Regiment. This appointment aroused hostile criticism from Thompson's fellow officers, who could not repress their indignation on learning that a young man, not yet of age and without military knowledge, had been raised above veterans whose long service justly entitled them to advancement. It will be shown presently that this incident prevented Thompson from engaging in the revolutionary struggle and led him to foreign lands where his genius had a wider field for

BIRTHPLACE AT WOBURN, MASS.

development, and where he soon became closely associated with the most learned and accomplished men of Europe.

In 1774 he left Concord with his wife and infant child and returned to Woburn. Charges were circulated that he was unfriendly to the cause of American liberty, and soon after the battle of Lexington he was arrested, and confined at Woburn. His case was heard by the Town Committee of Correspondence, by whom he was released. The principal evidence presented against him was that he had employed on his farm two British deserters, who, wishing to return to the British army, applied to their employer to secure immunity from punishment. Thompson complied by giving them a letter to General Gage, in which he asked that his efforts in their behalf be not disclosed.



Rumford's Statue at Woburn.

Major Thompson sought to redeem his reputation by entering the continental army. He applied to General Washington, then at Cambridge, for a position in the artillery, but his enemies had preceded him and his services were declined.

Deeming it imprudent to longer remain at home, he left Woburn in October, 1775, boarded a British vessel at Newport, by which he was conveyed to Boston, where he remained until the British evacuation. He then sailed for England bearing despatches to Lord Germaine, announcing the fall of Boston. Altogether Major Thompson was a bearer of bad news, friendless, poor and but twenty-three years of age, yet he so impressed Lord George Germaine with his intelligence, graceful manners and knowledge of American affairs that he was at once taken into his employ. In less than three years from the time of his arrival in London, he was advanced to the position of under secretary of state.

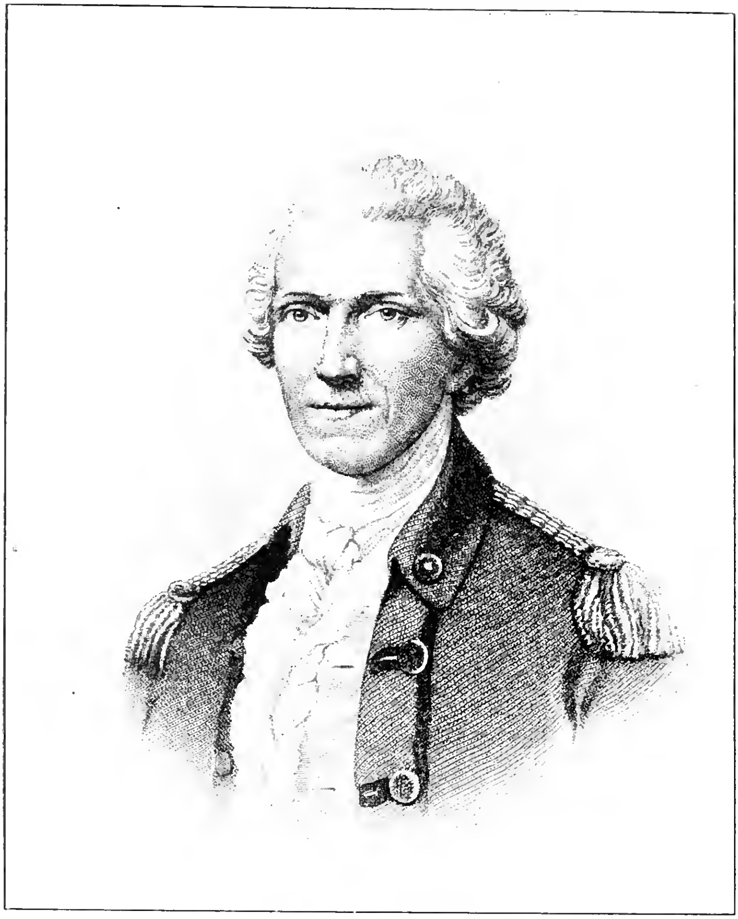
Judge Curwen, a tory refugee from Salem, Mass., then residing in London, wrote in his journal:

> This young man, when a shop lad to my next door neighbor, ever appeared active, good natured and sensible; by a strange occurrence of events he is now the Under Secretary of State to Lord George Germaine. His income arising from this souree is, I am told, near 7000 Pounds a year. He is besides a member of the Royal Society.

Thompson made a series of experiments to test the cohesive attraction of different liquids, the results of which he communicated to Sir Joseph Banks, as a means of introduction to that eminent naturalist, then president of the Royal Society. This self-introduction was so successful that he was placed in Sir Joseph's intimate circle of friends, and he soon became one of the most active members of the Royal Society.

His activities were prodigious. He made a careful study of military details; advised and procured the adoption of bayonets for the fuses of the Horse Guards for fighting on foot; extended his experiments with gunpowder; determined the proper position for the vent in fire arms; measured the velocity of bullets and cannon shot; determined the rapidity of combustion and pressure of gunpowder; published a pamphlet on naval architecture; made a series of experiments in firing broadsides with the frigates of the Channel Fleet, commanded by his worthy friend Sir Charles Hardy; cultivated the acquaintance of men of station and distinction everywhere; and in addition to all of the above—as under secretary of state—he had the oversight of the details of recruiting, equipping, transporting and victualing, the British forces.

When the official news of the surrender of the British forces at Yorktown reached London, Lord George Germaine and his under secretary were obliged to resign, because of the fall of the administration of



Portrait at Thirty Years of Age.

Lord North. The friendship of Viscount Sackville secured for Thompson a commission of lieutenant colonel in the British army, and he sailed for New York to command a regiment of cavalry, but contrary winds compelled the ship to enter the harbor of Charleston, S. C., where he remained for several weeks, finally reaching New York in January, 1782. The war soon being at an end, he left for England in the following April, after seeing but little actual service in America.

Having been advanced to the full rank of colonel, and there being no activity in the British army, he determined to add to his fame by volunteering in the service of Austria against the Turks. On receiving permission from the King to visit the continent, he left England, still holding his commission and drawing the half pay of a colonel.

He was now thirty years of age, strikingly handsome, with bright blue eyes, dark auburn hair, nearly six feet in height, athletic, a graceful horseman, a skillful swordsman, spoke French and German, thus possessing all the accomplishments of a veritable Admirable Crichton.

When crossing the Channel his fellow voyager was the historian Gibbon, who, in writing to Lord Sheffield, described his companion as "Secretary, Colonel, Admiral and Philosopher Thompson." On arriving at Strasburg he found a military review in progress, commanded by Prince Maximilian of Bavaria, then field-marshal in the service of France. Thompson had taken several blooded horses with him from England, and he appeared at the parade mounted on one of his English thoroughbreds in the full uniform of a colonel in the dragoons. He at once attracted the attention of the prince, who invited him to dine, and was so delighted with his company that he asked him to pass through Munich, giving him a letter to his uncle, the elector of Bavaria.

Although he spent but five days at Munich, he so captivated the elector that he was earnestly invited to enter his service; but still desiring to engage in military service, he continued his journey to Austria. At Vienna he was presented at court, mingled with the first society, and received the most flattering attention. While still at Vienna he received another pressing invitation from the elector of Bavaria to return to Munich.

Finding that the war with the Turks was at an end, and deciding to accept the elector's offer, he returned to England for the purpose of obtaining the king's permission to serve the elector. In granting his request, George III. conferred on him the title of knighthood.

This soldier of good fortune now entered Bavaria as Sir Benjamin Thompson, soon to be privy counselor of state to the elector. Only twelve years had elapsed since he had taught school in small New England towns, and only fifteen years since he stood in the streets of Boston selling fire wood that he had cut with his own hands and hauled to town. On his arrival in Munich, his energy and enterprise were allowed full scope. He at once began reforms in the army by improving the arms, clothing and sleeping quarters of the troops. For the production of supplies he established military workshops, employing soldiers that had before been idle. The subject of idleness and pauperism engrossed his attention, and he addressed himself to the solution of their causes and the remedy. Schools were established in all the regiments for teaching reading, writing and arithmetic. The soldiers, their children and the peasants were taught gratuitously. As a result, ignorant, idle soldiers became intelligent laborers, proud of their work.

Thompson was the inventor of our modern system of charity organization. Bavaria was swarming with beggars. He proposed to make them industrious and self-supporting; to make them happy first and virtuous afterward. A large building called the House of Industry was equipped for spinning and weaving cloth. A series of halls was fitted up for clothiers, dyers, saddlers, knitters, etc. The military workshop besides giving labor to the soldiers at good wages had also paid a revenue to the government. The House of Industry for the poor proved equally successful.

Thompson says, "The beggars not only infested all the streets and public places, but they even made a practise of going into private houses, where they never failed to steal whatever fell in their way. These detestable vermin swarmed everywhere, and they had recourse to most diabolical arts and most horrid crimes in the prosecution of their infamous trade." He had a large building fitted up in the neatest and most comfortable way. The rooms were clean, warm and well

Royal Institution of Great Britain Founded by Rumford.

lighted. Food was served, teachers provided for those who required instruction, and generous compensation for all labor performed. In this asylum for the poor and unfortunate, no ill usage or harsh language was permitted. On New Year's Day, 1790, 2,600 beggars in Munich and vicinity were arrested. Thompson made the first arrest with his own hands; all were treated gently. They were gathered at the town hall and informed that they must beg no more. They were promised comfortable rooms, food and remunerative work if they would labor. His House of Industry and his system of dealing with poverty accomplished what was intended, and mendicity was subverted in Munich.

RUMFORD MEDAL OF THE ROYAL SOCIETY.

His humane and practical methods of suppressing beggary gave him the title of "The Father of the Indigent." While he was dangerously ill, the poor of the city marched in procession to the cathedral and offered up prayers for his recovery. "Imagine my feelings," said he, "upon hearing the confused noise of the prayers, of a multitude of people, passing in the streets, when told that it was the poor of Munich, hundreds in number, who were going in procession to the church to put up public prayers for me—for a private person—a stranger—a protestant."

Thompson's essays on heat and light had been published by the Royal Society in their "Philosophical Transactions." He had been made a member of the Berlin Academy, and of several scientific societies of Bavaria, and later a member of the Institute of France. The elector advanced him to chamberlain, major general, head of war department, chancellor of state, and in 1791 conferred on him the title of Count of the Holy Roman Empire.

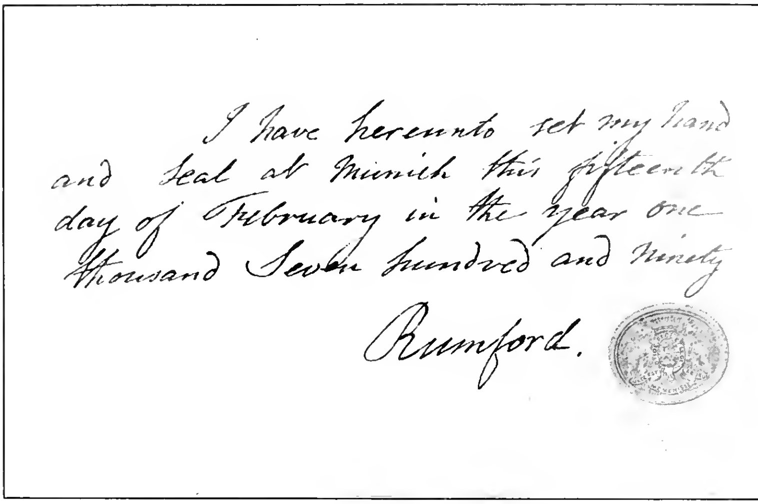
Concord, New Hampshire, was incorporated in 1734 under the name of *Rumford*, and in choosing his title, Thompson selected the early name of the American town where he had lived.

RUMFORD MEDAL OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES.

Portrait at Forty-five Years of Age.

One of the beneficent acts of Count Rumford was that of establishing a public park, called the English Garden. A neglected tract of forest in the environs of Munich that had been a part of the hunting grounds of the elector was by him converted into a beautiful park surrounded by a drive six miles in circuit. Its lovely lakes, walks, grottos, waterfalls and other charming features, are still alluring to a population fond of living in the open air. Within the park is a monument to the memory of its founder, a massive quadrangular structure of freestone. On one side is a bas-relief of Count Rumford in alabaster, below this is the inscription:

To him who rooted out the greatest of public evils,
Idleness and Mendicity, relieved and instructed
the poor, and founded many institutions for
the education of youth.
—Go, Wanderer, and strive to equal him in genius
and activity, and us in gratitude.


I have hereunto set my hand and Seal at Munich this fifteenth day of February in the year one thousand Seven hundred and Ninety

Rumford.

AUTOGRAPH AND SEAL OF RUMFORD.

On the opposite side is the following:

Rumford, the friend of mankind, by genius,
taste and love inspired, changed
this once desert place into what thou
now beholdest.

His health being impaired, he spent more than a year in Italy, and then returned to England after an absence of eleven years. On entering London he met with a terrible loss, which he never ceased to bemoan. While passing St. Paul's churchyard in the evening, his post-chaise was stopped and a trunk containing all his private papers was cut from its fastenings and stolen. He said: "By this cruel robbery, I have been deprived of the fruits of the labor of my whole life and have lost all that I hold most valuable."

Rumford's wife had died in 1792 and his daughter, who was an

PROFILE PORTRAIT. (BAS-RELIEF.)

infant when he left America, now a young lady, joined him in London and lived with him for many years.

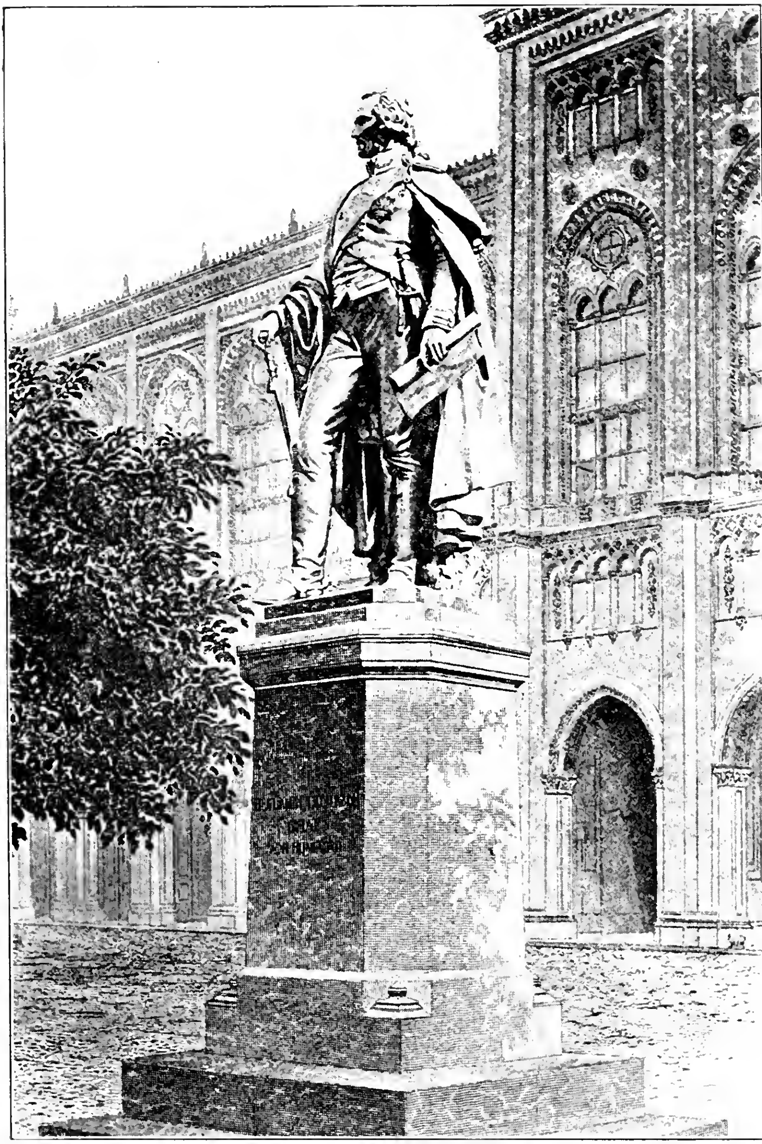
He was now forty-two years of age, and the main purpose of his return to England was to publish his essays. Several editions were subsequently brought out in both Europe and America, and they have been translated into German, French and Italian. While on this visit he presented a fund of one thousand pounds to the Royal Society, the interest of which was to be awarded every second year to the author of the most important discovery in light and heat. The society decided that the awards should be made in the form of medals, one of gold and one of silver, which together should contain an intrinsic value equal to the interest.

Rumford, at the same time, gave $5,000 to the American Academy of Arts and Sciences, of Boston, to be used in the same way. In 1837 this fund had increased to $20,000. It has now grown to $59,000 and the annual income is $2,550. Up to 1905, the Rumford premium had been awarded but twenty times. The academy has, however, made a great number of grants of money from the fund to assist those who are making researches in the phenomena of heat and light, and by a decision of the Supreme Court of Massachusetts, a portion of the income from the fund has been diverted to Harvard University. The Rumford professorship of Harvard will be referred to later.

After remaining a year in England, Rumford, accompanied by his daughter Sarah, returned to Munich. Here they occupied a palace supplied with every elegance, convenience and luxury. They were also permitted to use the princely summer residence of the elector, with its extensive park and mountain scenery. His daughter was made countess of the empire and allowed a pension of 2,000 florins for life.

When Napoleon repulsed the Austrians at Friedburg they retreated towards Munich, followed by the French. The elector, delegating Rumford with full authority, left the city, taking refuge in Saxony. Count Rumford at once employed his military talents to meet the emergency. He took chief command of the Bavarian forces, determined to prevent both the Austrians and French from entering the city. The gates were ordered closed and the Austrian forces occupied the opposite side of the river, where they planted their batteries. By a show of force, firmness and presence of mind, he was successful in preventing the occupation of the city by a foreign force.

In 1798 he was appointed Bavarian minister to the court of St. James's. It was a thing quite unprecedented to receive at the English court a subject of Great Britain as a representative of a foreign country, and it was one of the great disappointments of his life when informed that, being a British subject, he could not be received in a diplomatic capacity. He did not receive information of his ineligibility until he had arrived in London in company with his daughter.

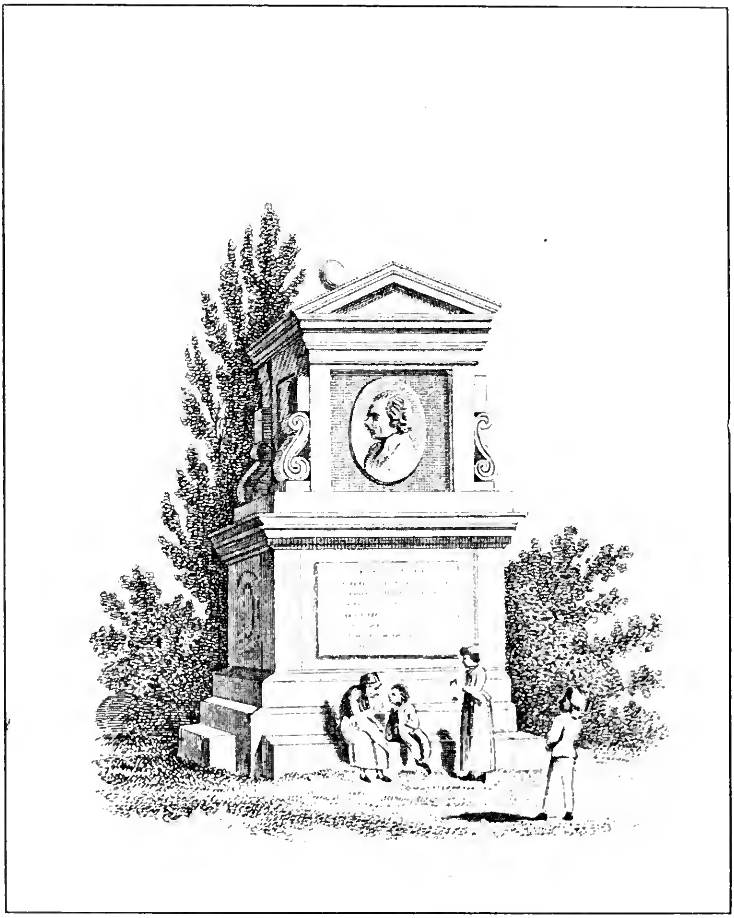


Rumford's Statue at Munich. Erected by the King.

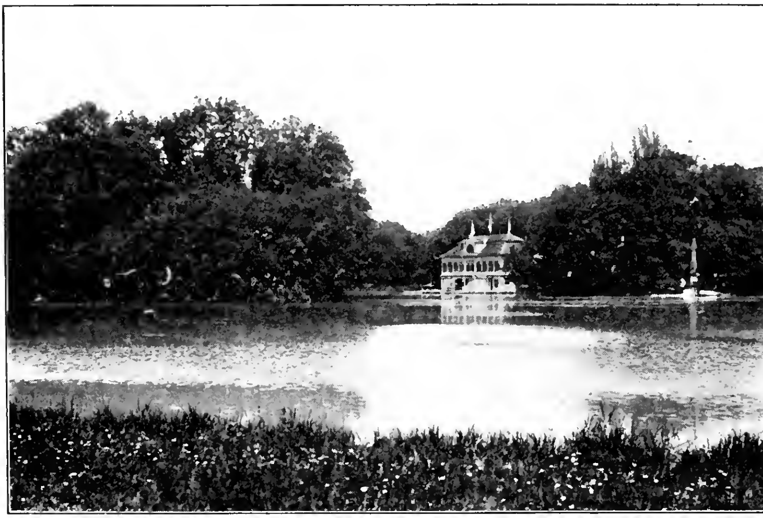
Rumford had always intended to take up his permanent residence in the United States, and he now proposed to establish himself near Cambridge, Mass. He wrote to his friend, Col. Baldwin, to find a desirable property, suitable to his intentions. To encourage his return to his native country, President John Adams instructed the American minister at London to write him as follows:

> We have made provisions for the institution of a Military Academy, and I wish to commit its formation to your experience and its future government to your care. In addition, I am authorized to offer to you the appointment of Inspector General of Artillery.

Although his plan to return to America originated with himself, he concluded that his obligations to the Bavarian government were so great and his relations with the institution, which he was now establishing, were so important, that they should not now be relinquished.



MEMORIAL ERECTED TO RUMFORD IN ENGLISH GARDEN.



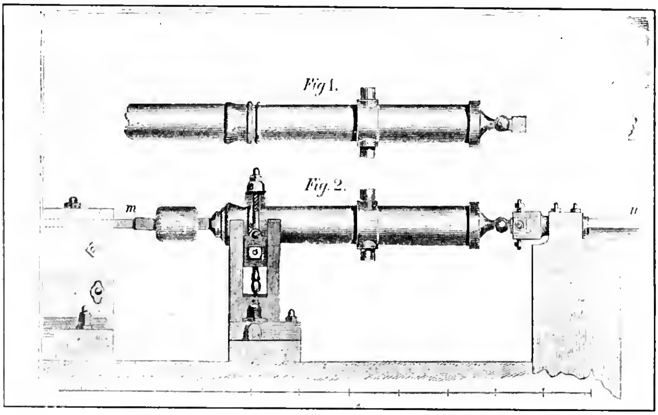
VIEW IN ENGLISH GARDEN.

He had already published a plan for founding a chartered organization to be known as the Royal Institution of Great Britain, its object being the promotion and extension of science and of useful knowledge, and the application of the same to the common purposes of life. The movement at once received the support of the learned men of England; the nobility and the king appeared as patrons.

The charter was granted in January, 1800, and Rumford was appointed the first manager, to serve three years. He had been living at his house in Brompton Row with his daughter, the countess, who now wished to return to America, and, on her departure, Rumford took up his residence in the rooms of the Royal Institution. It proved to be a perfect scientific Elysium for him, being supplied with every implement for experiment that he could suggest.

The founding of this institution was his crowning work in England. It is still a monument to his genius, practical intellectual activity and to his interest in the diffusion of knowledge. He employed Humphry Davy, then little known, as the first lecturer. Faraday afterwards joined Davy and for thirty-eight years was a lecturer there. These geniuses received small compensation at the beginning of their careers. The institution allowed Davy 100 guineas a year and Faraday 25 shillings a week; both were furnished coal, candles and lodging rooms.

The writer was a visitor at the Royal Institution last year and found it a flourishing organization of great influence. The Duke of Northumberland is president and Sir William Crookes, secretary. Among its professors are Lord Rayleigh, Joseph J. Thomson and Sir James Dewar. The laboratories are splendidly equipped for research work,



DRAWING BY RUMFORD, ILLUSTRATING HIS EXPERIMENT AS TO NATURE OF HEAT.

involving the provision of the most costly and complicated apparatus. No institution in the world can boast such a record of original research and important discoveries as that of the Royal Institution for the last one hundred years. Public lectures by eminent investigators are given in the lecture room. Weekly meetings are held by the members. There is a library of 60,000 volumes, and a reading room containing journals, magazines, etc. Here are preserved the historical apparatus of Davy, Faraday and others. Some of the models of Rumford's inventions are to be seen and his portrait, as founder of the institution, appears as frontispiece of the society's pamphlet.

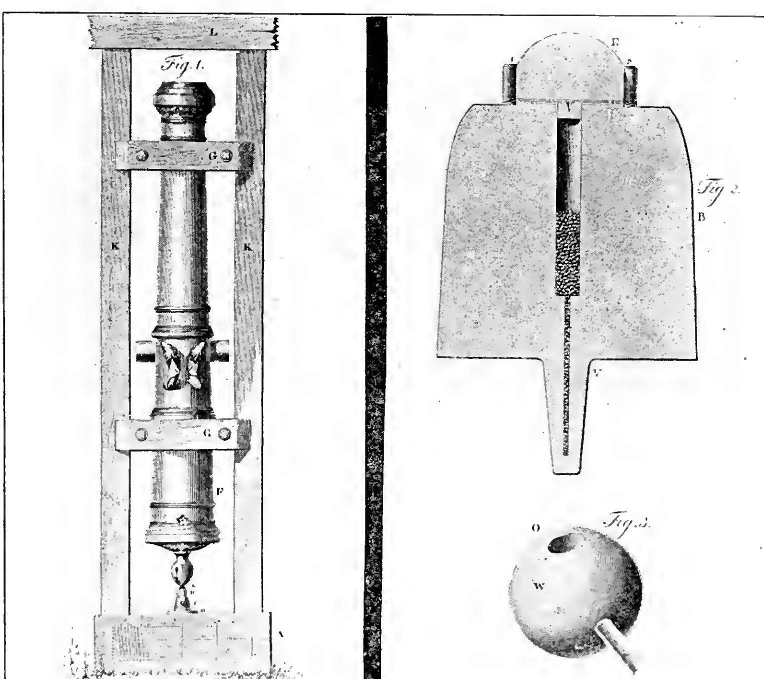
In 1801 war with France had paralyzed industry in England, and Rumford interested himself in practical methods for relieving the poor. On his recommendations, public kitchens were established in all the great towns of England and Scotland. Sixty thousand people were fed daily from the public kitchens in London. The same plan for feeding the poor was adopted in Paris, and the name of *Rumford* was printed on the tickets issued to the poor authorizing them to receive food. In Geneva the tickets contained Rumford's portrait as well as his name. He, at this time, wrote to his daughter—"My greatest delight arises from the silent contemplation of having succeeded in schemes and labors for the benefit of mankind."

Rumford left England for the last time in May, 1802. His intentions to return were defeated by the obstacles of war, and the next two years were spent between Paris and Munich, finally making his permanent residence in Paris.

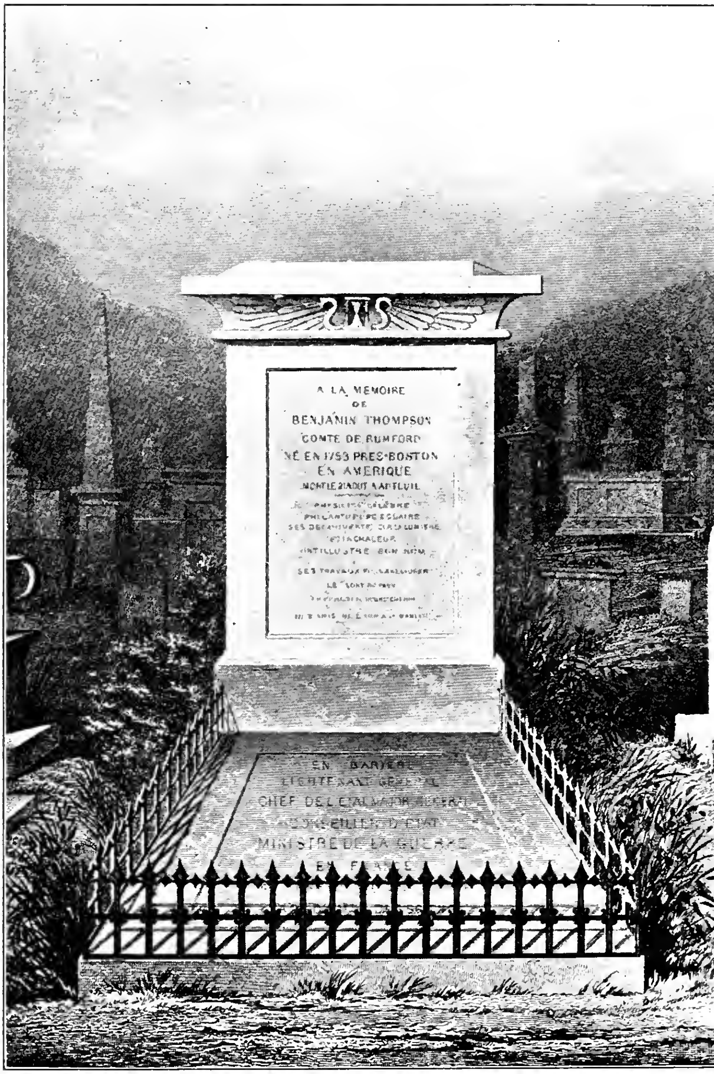
He was made a member of the Institute of France, and read more than a dozen papers before that body on the subjects of light, heat, combustion, illumination, etc. His lectures before the Academy of Sciences were beautifully illustrated by drawings of his own execution. Napoleon granted him the favor, as a distinguished man of science, to reside in France and draw his Bavarian and his English pensions, during the turbulent times of the empire. His reception in Paris delighted him. Parties were given him daily. The new elector of Bavaria wished to make him minister of state, but Rumford preferred to remain in Paris where were centered all that charmed him. His name was known everywhere, and the elector wrote him congratulating him on the cordiality extended to him by the French.

He soon married Madame Lavoisier, widow of the illustrious chemist who had perished, under the guillotine, a victim of the cruel Robespierre. They lived in rue d'Anjou, in the finest part of Paris. The salon of Madame Rumford was the last of the eighteenth century. Lagrange, Laplace, Guizot, Cuvier and Arago were frequent visitors. But the union of Count and Madame Rumford proved unhappy. Their characters and temperaments were incompatible, and after some domestic agitation a separation took place.

Rumford now leased a charming villa at Auteuil, which had been the abode of the celebrated Madame Helvetius, who had made it one of the chief literary centers of Paris, where our own Franklin was a favored guest. Two acres of gardens surrounded the house. It is said that Napoleon, when at St. Helena, recalled a remark made to



Drawing of Experiment with Gunpowder.



TOMB OF RUMFORD AT AUTEUIL.

him by Madame Helvetius while a visitor at this house. "Ah, General, if you only knew how to be happy within the bounds of two acres of earth!"

Rumford was delighted with his home at Auteuil. His daughter returned to him from America. He was occupied with scientific and literary pursuits, often reading papers at the Academy of France and occasionally making trips to Munich, in the service of Maximilian who had now been crowned King of Bavaria. Here he continued to live happily until seized with a sudden and violent fever. He expired August 21, 1814, in the sixty-second year of his age.

Baron Cuvier, the count's intimate and confidential friend, perpetual secretary of the French Institute, delivered the Éloge before his associates, in which he said: "It is an honor to France that a man who was held in such high esteem in the two most civilized continents, should choose France for a final sojourn. Here fuller celebrity is most surely awarded, regardless of favors of courts or the freaks of fortune." Here for ten years he had been honored by Frenchmen and by foreigners.

As a philosopher and physicist, Rumford ranks among the greatest of a period that was prolific in scientific research, discovery and invention. Before he began his investigations, the world was in almost absolute ignorance regarding the nature of heat. The metaphysical philosophy of the Greeks regarding the nature of heat, which had remained undisputed for two thousand years, was by Rumford overthrown and the phenomenon established on a mechanical basis. He disproved the theory of an "igneous fluid," or caloric, and conclusively proved that heat could not be a material body. He was the first to point out that energy and heat are mutually convertible, and that both are forms of motion. He was thus the founder of our modern science of thermodynamics.

While superintending the boring of brass cannons in the Arsenal at Munich, his attention was drawn to the great amount of heat acquired by the cannon and the high temperature of the brass chips. He investigated the source of this heat. A blunt borer was pressed with great force against the bottom of the bore hole in the cylindrical riser of a brass cannon. The cannon was rotated nearly a thousand times and the heat developed was sufficient to raise the whole cylinder, which weighed 113 pounds, to seventy degrees, while the amount of metal rubbed off by the borer was only 837 grains. He concluded that the supply of heat obtained from a given quantity of metal was inexhaustible, and hence heat could not be a material substance, but must be "motion."

He had a talent for inventing scientific instruments for making experiments. He thus invented the photometer, an instrument for measuring the relative intensity of different lights; the calorimeter, for measuring the quantity of heat; the thermoscope for indicating the difference of temperatures. He was an accomplished linguist, speaking and writing French, German, Italian and English with equal facility.

Rumford was buried at Auteuil. His monument bears the following inscription:

To the Memory of Benjamin Thompson,
Count Rumford.
Born in 1753 at Concord (?) near Boston, in America;
Died the 21st of August 1814, at Auteuil.
A celebrated Physicist.
An enlightened Philanthropist
His discoveries in Light and Heat have made
his name illustrious.
His labors for ameliorating the lot of the
poor, will cause his name to be cherished
forever by the friends of humanity.
— In Bavaria —
Lieutenant General, Chief of State
Major General, Counselor of State
Minister of War.
— In France —
Member of the Institute
Academy of Sciences.

No mention is made of the honors won by him in England.

In front of the government offices, in that great art center, the city of Munich, is a noble bronze statue of Count Rumford. The figure, clad in the uniform of a Bavarian general, stands ten feet in height. It was modeled by Professor Zambush, and erected by the King of Bavaria at his private expense.

Rumford's income had been a liberal one, but he did not leave a large estate. He was free with money and spent it profusely wherever his interests were concerned. Cuvier said: "Rumford lavished his own money to teach others how to save theirs." Both his mother and daughter were, by him, supplied with annuities, and at one time he sent his mother $10,000 to be used as she pleased.

The Count's last will was executed in 1812. Lafayette signed it as a witness. After providing for his daughter, he bequeathed to Harvard University an annuity of $1,000, and also made that university his residuary legatee. The bequest was for the purpose of founding a professorship to teach the utility of the physical and mathematical sciences. The capital sum received by Harvard University from the Rumford estate was $28,395. This has been increased until the "Rumford Fund" is now $56,441. The professorship was established in 1816. A fine portrait of Count Rumford hangs in the room of the Faculty of Arts and Sciences, No. 5, University Hall.

In the summer of 1906 the writer made a pilgrimage to the grave of Rumford. After passing the fine statue of Franklin, in the Place du Trocodero, the rue Franklin was followed to the rue de Passy, thence to the rue Mozart, which leads directly to Rumford's house in the rue d'Auteuil. While ambassador to France, Franklin traversed these streets many times to visit his friend Madame Helvetius, who then lived in the house later occupied by Rumford. In his "Dialogue between Franklin and the Gout" Franklin is accused of taking too little exercise. Gout says: "Behold your fair friend at Auteuil. . . . When she honors you with a visit, it is on foot. In this see at once the preservation of her health and personal charms. But when you go to Auteuil, you must have your carriage, though it is no farther from Passy to Auteuil than from Auteuil to Passy."

Rumford's house appears to be much as it was one hundred years ago, although shorn of its two acres of gardens and now with shabby exterior. The front is enclosed by a high iron fence, with heavy gates and there still remains a suggestion of shrubbery and flowers. In 1870 this house was the scene of a tragedy in which Prince Pierre Bonaparte shot and killed Victor Noir, a young journalist, who had presented a challenge.

Half a mile southward in the Rue Michel Ange is the cemetery of Auteuil. It is surrounded by a high wall and contains probably more than half an acre of ground. The graves are much crowded and the paths narrow. No interments are now made there. The tomb of Count Rumford is near the south wall. The horizontal stone is perhaps six feet square; the vertical stone of about the same dimensions, and three feet thick. The material appears to be a soft marble, now so badly weathered that the inscriptions are illegible.

HYPOTHESIS OF RADIANT MATTER[1]

By MORRIS LOEB, Ph.D.

THE enormous literature which has developed from the discovery of radium and from the study of cognate phenomena has made it increasingly difficult to form a calm opinion upon the merits of all the claims which have been advanced, and upon the validity of the theories which have been based upon them. Undoubtedly, the great bulk of the experimental data is exact, although time may show that some of the experiments which were recorded before the technique was fully developed may require correction. Without questioning in the slightest degree the experiments reported by some of the skillful observers of modern times, one is, nevertheless, permitted to hesitate in adopting hypotheses that not only subvert formerly accepted ideas, but also seem, in many cases, inconsistent with one another.

The chemical world has been accused of accepting too dogmatically the theory of the conservation of matter, the indivisibility of the atom, etc. Ought we not, then, to guard ourselves against a similar fault in adopting newer views?

I propose to take up seriatim the methods of reasoning which have led to the present hypothesis of radiant matter as expressed by its chief exponents, and to indicate some points which seem to me to be inconsistent with older views, or in conflict with one another; and I shall begin with what may, from the present point of view, be called a static phenomenon, the behavior of the atom toward light. It is known that Lorentz modified Maxwell's electro-magnetic theory of light, by assuming that the vibrations from which light-waves originate are not produced by the atom as a whole, but rather by the vibration of its positive or negative electric charge, conceived as a special entity, which we may now personify, as it were, by the more recently coined name electron. The electron vibrates in an elliptical path which is really the result of two circular oscillations in opposite directions, and of differing amplitudes, but of identical period. An alteration of the radii of these circles would merely alter the shape of the ellipse; but if the *periods* of the two circular motions were made to differ, no single resultant could appear, for the two vibrations would produce waves of different length, *i. e.*, light rays of different refrangibility. Now, a magnetic strain

[1] Extracts from a review presented to the New York Section of the American Chemical Society at its meetings, November, 1907.

ought to exert some influence on an electron; if it accelerated its dextro-gyratory motion, it would retard its lævo-gyration, or vice versa. This is precisely what Zeeman found when he examined the emission-spectra of vapors that were placed in an electro-magnetic field; single lines are broken up into two or more finer lines, placed symmetrically with regard to the position of the original one. Righi has generalized the reasoning so that it covers practically every relation between the vibrating electron and the external magnetic strain to which it is subjected, and reaches two conclusions: First, the vibrating electron is electro-negative; second, the ratio e/m, *i. e.*, electric charge over mass, is about 1,000 times as great as the ratio between the electric charge and mass of the hydrogen ion. Assuming, perhaps arbitrarily, that the electric charge is the same, the mass of the electron is about 1/1,000 that of the hydrogen ion; it can be no mere coincidence that Thomson, Kaufmann and others arrive at virtually the same figure for the mass of the corpuscles which carry the negative charges in ionized gases of whatever chemical constitution; in fact, everybody recognizes their identity.

To quote Righi, the neutral chemical atom (as distinguished from the ion) consists of a central mass of positive charge, around which revolve as satellites one or more electro-negative corpuscles, retained in their orbits by some centripetal force.

In connection with this definition, the following points seem to require emphasis: the number of electrons per atom are few, practically corresponding to the valency; this seems to be corroborated by recent experiments of Becquerel on the phosphorescence of uranium minerals at low temperatures, which likewise point out that light-emission is not always confined to the negative corpuscle, as Righi would have it. The total mass of the free electrons in an atom is not sufficient to affect the ratio between specific heats for constant pressure and constant volume of monatomic vapors, like mercury and cadmium; their velocity in their orbits does not approach that of light, and they have no high momentum retained by comparatively powerful internal attractions. These electrons can not be identical with the X-particles which are projected with terrific force from the uranium, radium and other atoms, according to Rutherford and his followers.

I need only touch briefly on the electric discharges in vacuum tubes: it is generally accepted that we distinguish Lenard or cathode rays, which are negative, and positive Goldstein or canal rays within the tube. They can be deflected by electric or magnetic fields, they produce mechanical and heating effects, cast visible shadows, etc., and they behave in general like streams of actual particles charged with electricity. When the cathode ray strikes an impenetrable obstacle, like glass, the X-rays are produced as a secondary effect: these do not behave as if conveyed by neutral particles; have vast penetrating power; contain no electric charge, as they are not influenced by magnetic or electric fields, and are neither refracted nor reflected. I would emphasize, however, their ability to discharge an electrometer, as well as to influence the photographic plate. Their peculiarities have been recently ascribed to the fact that they represented aperiodic impulses given to the luminiferous ether—which conveys no meaning to my mind, excepting that they can *not* be explained by the undulatory theory. The velocity of the canal rays has been determined, and the mass of their hypothetical particles measured by the amount of their deflection in magnetic fields of varying strength; both values approximate those found for the ordinary chemical atoms or molecules; in the case of the negative cathode rays, however, the velocities and mass correspond to those assumed for the electrons. I confess to a serious difficulty in harmonizing the notion of a corpuscular structure of the atoms with the explanation given by the same school for the need of high vacua for the production of cathode rays. It is said that the electrons must have a considerable free path in order that they may travel with undiminished velocity toward the anode: but if the atoms, instead of being compact elastic bodies, be mere nebulæ of electrons, the relation of whose sizes and interstices is comparable to that of the molecules in a normal gas, it follows that a free electron, hurled vehemently forward from the cathode, could pass quite through a number of atoms without collision with any of their constituent corpuscles; the free path of the electron is so enormous, on this hypothesis, that the order of its magnitude could not be materially affected by the degree of rarefaction of the gas customary in the Crookes tube.

We must recollect, however, that the hypothesis, first elaborated by Larmor, that the electrons are the primordial constituents of the atoms, does not, like that of Prout, simply extend the limits of the divisibility of matter. The electron is not to be considered as a small speck of matter at all, but as a permanent manifestation of energy concentrated on a minute portion of the luminiferous ether. This view and the explanation of many phenomena on such a basis has been acclaimed as the triumph of energetics, the final elimination of the conception of matter. An unbiased reading of J. J. Thomson's Yale lectures, however, will impress anybody that he decidedly *materializes* both energy and ether. Perhaps much of this materialization is purely symbolic, to bring his mathematical reasoning within the comprehension of his audience; but to me it seems that an electric charge which has quantity, mass, inertia, elasticity and expansibility, which obeys the laws of hydrostatics, and virtually has a surface beyond which it can only produce effects by the medium of mysterious lines of force, has a marvelous resemblance to the picture which the ordinary chemist's mind would form of material substance. His ether is not only that puzzling paradox, at once impalpable and inconceivably dense, rigid and frictionless, which we have accepted as the whole means of explaining the transmission of motion through a vacuum; to extend its importance as the substratum of *all* phenomena it must become heterogeneous and capable of deformation; to form a neutral atom, some of it must become a spherical jelly in which other parts of itself are imbedded as rigid particles. It has, consequently, different degrees of hardness, and is subject to internal attractions. Thomson even volunteers the admission that, for the explanation of certain phenomena, his ether must have structure, or, at least, be stratified.

This can, of course, be no insinuation against the work of some of the greatest living physicists and mathematicians: accepting their premises, I do not doubt that they have drawn the consequences in the most rigid fashion. I do assert, however, that some of their fundamental terms are used in a different sense from that to which we are accustomed, and that we are, therefore, entitled to doubt whether the conclusions which they reach really affect the phenomena with which the chemist deals: as if one were to discuss the crystallographic structure of Pentelian marble with reference to the architecture of the Parthenon.

A few examples, pertinent to our inquiry, will more precisely establish my meaning. One of the fundamental postulates of Professor Thomson's mathematical argument is the definition of momentum as the product of mass by velocity. Although this is not axiomatic, we accept it as such by reason of the many ballistic experiments which have proved its truth, so long as the projectile's mass was assumed to remain constant: we should hesitate if we were told that mass was to vary, *i. e.,* that a bullet which weighs the same before and after the shot, was heavier during its flight. But the momentum of Thomson's electrons increases faster than their velocity, when the latter approaches that of light; hence, he says, the mass of the electrons increases with their swiftness. True, he calls it an electro-magnetic mass, but some of his followers have forgotten the distinction. At all events, his terms momentum and mass must not be accepted by us in their usual meaning.

It is perfectly true that Thomson's calculations are corroborated by Kaufmann's experiments on the velocity of radium rays in combined electric and magnetic fields, if the latter's data are calculated according to Thomson's views; without even seeking a radically different basis—which would not be difficult—we can follow Thomson to a point where his departure from ordinary assumptions becomes evident. He shows that the value e/m diminishes at high velocities and then he assumes that e, the electro-static charge, is constant; therefore m, the mass, varies. Now, the value of e is derived from Faraday's law, which would never have been announced if Faraday had not dealt with the equivalent weights as fixed mathematical quantities. In fact, just so far as Thomson substantializes electricity by giving it atomic structure, with invariable mass, the chemical atom becomes wavy and matter evanesces into the ghost-like form which energy has assumed in the chemical mind. If our scientific terms are, as it were, to receive the reciprocals of their present significance—progress may ultimately result, but we should enter into topsy-turvydom with our eyes open.

The electron theory possesses the merit of furnishing a working hypothesis upon which to coordinate the various electrical phenomena of vacuum tube and radio-active origin: chief among which is the increased conductivity of gases. Either direct current measurement or the more sensitive electrometer, determinative of the decrease of electro-static potential, indicates that gases begin to conduct electricity when affected by ultra-violet light, by cathode and X-rays, by radium, thorium, etc. Ingenious experiments have proved that portions of the gas are positively, others negatively, charged; that they behave as if ionized; the numbers, masses and charges of the hypothetical ions have been measured and found to agree with the assumption that the negative ions have the magnitude of the electrons, the positive ions that of the regular molecules, *i. e.*, the negative ions are always very small and mobile, with the same value for all gases; the positive ions are, at least, 1,000 times as large, and vary for different gases. If the gas moves away from the locality of ionizing influence, its conductivity disappears gradually at a rate to suggest reunion of the ions. Plausible, if not quite conclusive, reasoning connects the ionization hypothesis with the novel phenomenon of the saturation constant; viz., the fact that the flow of electricity through a conducting gas increases proportionately to the voltage between the electrodes up to a maximum, when further increase of potential has practically no effect on the current. This saturation current, it may be remarked, is used to characterize radio-activity; it is admittedly a complex phenomenon, and I should be inclined to lay more stress upon the qualitative than the precise quantitative results obtained in a number of recent experiments.

Those who, like Armstrong, oppose the electrolytic dissociation hypothesis of Arrhenius, naturally attack the ionization hypothesis with still greater vehemence, and I believe that this will be the battleground of opposing theories for some time to come. As the phenomenon is distinctly a secondary reaction, from our point of view, we need not discuss it in its various aspects, beyond noting that even without detectable radio-active agencies the atmospheric air conducts electricity to a slight extent, varying with location, as well as with the hours of the day.

The radiations from the active chemical substances present a very complex aspect; besides light and heat, radium and its congeners send out α, β and γ rays, respectively electro-positive, electro-negative and neutral when tested in electric and magnetic fields.

From radium α rays are sent out about four times as abundantly as β rays, the γ variety being relatively few. α rays are electro-positive, have a speed one tenth of the velocity of light, and a molecular mass of atomic magnitude. They penetrate a few centimeters into air, pass through thin aluminum foil but are stopped by denser metals. As they are but slightly deviable in a magnetic field, their momentum is calculated to be enormous: until, however, better evidence of the total positive charge which they carry has been obtained, we can not consider the magnitude of the momentum as definitely established; especially since their speed does not appear to be uniform. From experiments wherein α particles are allowed to escape freely, and again restrained by a lead cylinder surrounding radium, much of the apparent heat of the latter body appears to be due to the impinging of the α rays upon the surrounding surfaces.

β-Rays are similar to cathode rays; they are less absorbable than the α variety, and proceed at various speed, many approaching the velocity of light; they are stopped by solids in proportion to their density.

γ-Rays are similar to X-rays, of great penetrating power, and they are thought by some to be secondary effects of α and β rays, just as the X-rays originate from the impact of cathode rays on the glass wall of the Crookes tube. Besides, we have a multitude of conflicting accounts of secondary tertiary rays, resulting from these three varieties.

The chief method of research is the study of ionization, with the interposition of screens and magnetic fields, to separate the different kinds of rays. On the other hand, the varieties of rays emitted, their relative strength, and their variations of intensity, are the characteristics upon which the identification of the various so-called transformation-products of radio-active material is based. I have, therefore, copied from Professor Rutherford's book[2] tabulations of these properties.

With regard to these various transformations, we should realize that the majority of the names are titles of hypothetical substance, whose existence within certain mixtures is assumed upon the evidence of their momentary radio-activity. The only one really isolated is that emanation which has all the properties of a gas, including that of condensibility at low temperatures—with the exception that its liquid form shows no vapor pressure—but has in addition remarkable energy effects, and has, undoubtedly, undergone transformation in Ramsay's hands. Bearing in mind the infinitesimal quantities of emanation which Ramsay and his associates could obtain, we are alike astounded by their marvelous manipulative dexterity and by the nature of their observations. First we had the gradual appearance of helium, when the emanation was stored by itself; then came the appearance of neon, when the emanation came into contact with water, the latter being partially decomposed into oxygen and hydrogen; lastly the partial reduction of copper nitrate solution, with the simultaneous appearance of lithium,

[2] "Radio-activity," 1905.

Transformation Products of Thorium, Actinium and Radium according to Rutherford

Product	Time to be half transformed	Radiations
Thorium ↓	—	α rays
Th. X ↓	4 days	α rays
Emanation ↓	54 seconds	α rays
Thorium A ↓	11 hours (Active Deposit)	no rays
Thorium B ↓	55 minutes (Active Deposit)	α, β, γ rays
?	—	—
Actinium	?	no rays
Actinium X	10.2 days	α (β and γ)
Emanation	3.9 seconds	α rays
Actinium A	35.7 minutes	no rays
Actinium B	2.15 minutes	α, β and γ
Radium ↓	1,200 years	α rays
Emanation ↓	3.8 days	α rays
Radium A ↓ (Active Deposit of Rapid Change)	3 minutes	α rays
Radium B ↓ (Active Deposit of Rapid Change)	21 minutes	no rays
Radium C ↓ (Active Deposit of Rapid Change)	28 minutes	α, β, γ rays
Radium D ↓ (Active Deposit of Slow Change)	about 40 years	no rays
Radium E ↓ (Active Deposit of Slow Change)	6 days	β (and γ) rays
Radium F (Active Deposit of Slow Change)	143 days	α rays
?	—	—

while the emanation underwent a change into argon. The lithium, we are assured, could not be found in the original materials; it represents about .01 per cent. of the sodium and calcium found in the same experiment; its actual amount, after correcting a slight oversight in Ramsay's estimate, would be 0.00000003 gram. For such a quantity the amount of copper transformed would be too minute for the detection of a loss from the 0.3 gram of copper which the original solution may be assumed to have contained: but, until a loss of copper be ascertained, to correspond with the gain in lithium, it appears to me that the assumption of transformation is premature. Ramsay found that this solution contained in all 1.67 mg. alkaline chlorides, chiefly sodium chloride; while 0.79 mg. were produced in a blank experiment, when the emanation was excluded. While this latter amount is admittedly derived from the glass bulb, the excess obtained in the presence of emanation is ascribed to the degradation of the copper, neglecting the fact that this second solution must have been fairly acid and would, therefore, have attacked the glass more vigorously. Accepting his suggestion, however, the deficit of copper ought to approach 0.8 mg., an amount which ordinary analysis can detect. We may, therefore, hope that further experiments by Professor Ramsay will throw light upon this side of the subject.

Of Ramsay's present conclusion, the following résumé may be given: Emanation is a gas of about atomic weight 216.5, derived from radium, of atomic weight 225, simultaneously with α-particles which are *not* helium. When emanation and the α-particles are shut up together, the bombardment of the latter breaks up the emanation into helium; but if heavier molecules, like water, be present, they receive some of the bombardment, and the emanation is only degraded into neon; the pressure of copper nitrate still further protecting the emanation, so that it only breaks down to argon. This kinetic explanation is not impeccable; for, according to the principles of mass-action, the preponderance of water molecules in the copper nitrate solution, as well as the predominance of hydrogen and oxygen in its decomposition products, would imply the presence of considerable amounts of neon to accompany the argon. As neon is said to be absent, we must either seek for some other hypothesis or explain how the neon reverts to argon after it is once formed.

Ramsay's views contradict those of Rutherford and others, who seek to identify helium with the α-rays, and the latter would thereby lose a good deal of their substantive character. Furthermore, it is to be noted that the α-particles bear positive charges: if they were merely chemical atoms, such a charge might possibly be obtained as they tore themselves loose from the larger complex, during radiation; but if they be non-substantive masses of free energy, it will be difficult to reconcile the various assumed transformations with the electro-chemical properties, valencies, etc., of the elements in question.

It must be recalled that Rutherford does assume that the successive transformations of radium, for instance, are effected by the expulsions of the α-particles and that these have *atomic* mass: an atom of radium, therefore, contains a finite number of them. As the transformations are atomic and not molecular, Rutherford's application of the mathematics of mass-action can mean but one thing: that the various rates of transformation depend upon the chances of encounter and relative positions of the particles *within* the atom. These rates, however, as measured by the period of decay, vary from thousands of years to a few seconds for the different educts, and that irregularly in the order of transformation—such great differences could only be explained by an infinite number of components, with large free paths, electrons, in other words. It would then remain to be shown what caused a certain great number of negative electrons to form an electro-positive α-particle, and become expelled with great violence from their surroundings.

Naturally, the failure of a hypothesis to explain certain facts does not invalidate the latter. Rutherford's brilliant analysis of the curves of increasing and decreasing ionization and the agreement observed with calculated results prove that he is not dealing with mere fortuitous coincidences. Many of his conclusions seem incontrovertible upon his premises; but here again, the *advocatus diaboli* must step in and ask whether the premises are axiomatic: two of them appear to me to be doubtful. (1) A curve of decay is based on electroscopic measurements upon the tacit assumption that the rays sent out by that particular phase are always the same; but we are told that both α and β rays vary greatly in speed and momentum, hence neither variety would show a uniform ionizing power; assuming that a substance did send out α rays for a long time, but that their velocities were gradually reduced, would not the ionization indicate a more rapid decay than was really the case? (2) It is practically assumed throughout that ionization is directly proportioned to the amount of radio-active material present: but this remains to be proven. Where layers of any density are involved, we know that it is not true, owing to internal absorption, etc.; for ideally thin layers, weighing and other measurement are out of the question.

I do not think that this latter objection ought to be dismissed lightly, when we find such a phenomenon as the almost universal ionization of the atmosphere ascribed to the presence of radium or its educts. Thomson himself has shown a variety of ways for ionizing air, when any variation in the amount of radium present—or, rather, absent—is out of the question; some of these serve particularly well to explain the phenomena in the open air. Recently, indeed, quite a number of investigators have observed diurnal variations in this atmospheric ionization, sufficiently marked to require some other explanation than the production of emanations from the earth or surrounding materials. Gustave Le Bon, in his "Evolution de la Matiere," shows how the gold-leaf electroscope is discharged when connected with some very dry sulphate of quinine, which is taking up hygroscopic moisture. Are we ready, with him, to assume that the quinine is catalyzing some atoms into nirvaña, or that the electroscope may indicate many changes that are not intra-atomic?

THE NEW PHILOSOPHY CALLED PRAGMATISM

By Professor H. HEATH BAWDEN
UNIVERSITY OF CINCINNATI

PRAGMATISM is a recent movement of thought which is seeking to do justice to the neglected claims of common sense, of religious faith and of science, in determining a true philosophy of life. It is, as Professor James says, simply a new name for some old ways of thinking, yet in its scope and depth of significance it promises to rank among the important and characteristic products of our Anglo-Saxon civilization.

Pragmatism originated as a logical principle of method, first formulated by Mr. Charles Peirce in 1878 in an article published in The Popular Science Monthly. Twenty years later, Professor James, in an address before the Philosophical Club of the University of California, brought Peirce's principle to the attention of the philosophical world, since which time those sympathetic with the general point of view have been rallying about it as an organizing center.

At the present time pragmatism is connected with the names of three men, in this country and in England, each being associated with a distinct phase of the movement. Professor William James, of Harvard University, emphasizes the practical meaning of philosophy for every-day life. Mr. F. C. S. Schiller, of Oxford University, England, defends the rights of religious faith and feeling in determining our beliefs. Professor John Dewey, of Columbia University, is the champion of a scientific empirical method in philosophy. Professor James uses the words pragmatism and radical empiricism to describe his point of view. Mr. Schiller prefers the term humanism and his philosophy has much in common with what in other quarters has come to be called personalism. Professor Dewey's method is quite generally known as instrumentalism, but in a recent article is described by Professor Dewey himself as immediate empiricism.

These three leading exponents of pragmatism may be regarded as meeting the objections urged, respectively, by the man of affairs, by the mystical religious man, and by the man of science.

The man of affairs has objected to philosophy in the past on the ground of its being abstruse and theoretical, impractical and dreary. He is unable to convert the speculations of the metaphysician into market values, on the one hand—it doesn't "bake any bread"—while, on the other hand, it unsettles his faith in the spiritual verities—"God, freedom and immortality"—belief in which he regards as essential to his peace of mind.

The answer which pragmatism makes to this objection of common sense is to admit its main contention. Concrete experience must, in the last analysis, be the test of the truth of ideas, and philosophy in the past *has* been out of touch with the interests of practical life. As Mr. Peirce and Professor James put it, there is no difference which does not *make* a difference. The test of theories must be found in practise. The pragmatic philosophy is a renewed emphasis of this truth. It is a philosophy of doing, and of knowing, only in relation to doing. It is a philosophy of work, of activity, of enterprise, of achievement. And for this reason it has taken up arms against all forms of transcendentalism and absolutism and dogmatism and apriorism in so far as these stand for intellectual interests which do not grow out of or minister to the needs of life.

But the pragmatic philosophy has one trenchent criticism to make on the attitude of the man of affairs—he stands in his own light, stands so close to his practise that he loses perspective, holding a nominal theory which does not correspond with the real theory of his practise. His attitude is essentially uncritical and primitive—naïve, total, implicit, rather than reflective, discriminating and definitive. In becoming practical, philosophy deals common sense a severe blow by showing its inconsistency and the narrowness and vulgarity, often, of its empiricism—for, after all, theories, while not action in an overt sense, are yet themselves just refined forms of adjustment in a complicated environment.

Another type of person, impressed deeply by the so-called spiritual things of life, by the values as opposed to the facts, believes that the realities which are of most worth are apprehended through the feelings and by faith rather than by purely logical processes, and objects to philosophy on the score of its being artificial and arbitrary, substituting formulas for vital experience and abstract propositions for warm concrete appreciations of things. This is the essentially mystical attitude which includes, not only the religionist, but the artist and many others who distrust the purely intellectualist way of looking at the universe.

Here, again, pragmatism admits the main contention of the objector. Philosophy too often, as Mr. Bradley says, is the finding of bad reasons for what we believe upon instinct, and a substitution of abstract impersonal laws for the living personal values of immediate experience. And this new philosophy called pragmatism is trying to so reconstruct the intellectual machinery as to meet the needs of this deeper emotional and volitional nature of man. In so far as pragmatism emphasizes the personal as opposed to the purely formal conditions of thinking, it may be described as mystical in the legitimate and good sense of the word.

This is the core of the humanism of Mr. Schiller. Faith underlies the hypothesis of scientific method as truly as the act of obedience in religion—not, however, in the sense of the child Mr. Schiller quotes, who says that faith is believing what you know isn't true, but in the sense rather of a legitimate speculation where all the factors are uncertain, in the sense of a prudent gambling or betting on your partial knowledge. If faith lies at the basis of our credit system in business and is the only sanction of the inductive leap in scientific generalization, why should it not be legitimate to take the risk of there being a God or a future life? For all we know, the wish and the will to believe may be a factor in determining the reality—as he who thinketh his friend to be true maketh him true.

Pragmatism, in this respect, is a protest against the cold intellectualism of the philosophy and science of the age. In mastering the means of living we have forgotten the ends of life. We confuse money with wealth, the church with religion, politics with government, the school with education, leisure with culture. But he fails in the having who spendeth his days in the getting. The values of life, as Hume long since taught us, lie in the alogical forces of the soul. Reason and the ratiocinative processes find their only justification in serving at once to satisfy and to modify the feelings and desires which underlie all other aspects of personality.

But still a third objection is frequently raised to philosophy by the man of science, and the pragmatic reply to this is contained in the new instrumental or functional theory of knowledge of Professor Dewey and his school. The man of science criticizes philosophy for being too theoretical in the sense of speculative, "not sticking to the facts." The metaphysician is prone, he says, to spin a universe out of his own inner consciousness, and tries to make the facts fit this ideal system. Once again, pragmatism meets the objector by admitting the force of his objection so far as past systems of philosophy are concerned, and seeks to win the cooperation of the scientist in constructing a philosophy which will be scientific in its method.

But the pragmatist reminds the man of science that he is not free from speculation in his own enterprise, that indeed hypothesis is one of the leading instruments of scientific research, while his whole procedure is shot through and through with metaphysical presuppositions which are the more prejudicial because unsuspected. The aim of a pragmatic philosophy is to bring metaphysical speculation to the test of scientific exactness, on the one hand, and, on the other, to help the scientist to bring to clear self-consciousness his own logical assumptions. This involves, not only a new conception of philosophy, but a new conception of science in relation to philosophy.

The wings of metaphysical speculation are clipped, but philosophy no longer is relegated to the left-overs. Its subject-matter as ordinarily conceived is the methodological scrap-heap of the scientist. All the residual problems which science shoves aside as unimportant or irrelevant are turned over to philosophy, which, as the various sciences successively split off from the parent-stem, has to be satisfied with the vague chaos of general opinions which have not yet come under scientific scrutiny. On such a view philosophy, of course, never can hope to occupy a position of dignity in the intellectual world, for as soon as the human intellect takes up seriously one of these remaining problems and subjects it to careful experimental study, it ceases to be called philosophy and is scored to the credit of science. The result is that the field of philosophy becomes more and more restricted until finally science occupies the whole field and philosophy has only a historical significance.

The name, to be sure, is unimportant—whether it be called philosophy or science—but the fact is that as science gradually encroaches upon the field of the so-called philosophical subject-matter, her method has been becoming more and more philosophic: that is to say, with the progress of science it becomes increasingly necessary to go beyond the confines of any particular science in order to explain any one of its facts. Hence the appearance of the hyphen-sciences and of the comparative method, which have grown up in the interstices between the sciences as formerly classified. Now, in so far as an explanatory law extends beyond the province of the particular science, it is what, in the history of thought, has been called a philosophical principle, and inasmuch as science to-day is increasingly comparative in its method, it follows that it is becoming increasingly philosophic. Instead of philosophy being condemned to the unclassified residuum, it is becoming the very methodology of science. Each scientist is perforce becoming philosophic in order to understand the implications of his own procedure. It behooves the man of science to realize this, and it behooves the old-fashioned metaphysician, who supposes that his method is distinct from that of science, to realize that the only fruitful philosophizing that is going on at the present time is at the hands of the philosophic scientists and the scientific philosophers.

One of the main contributions to this new conception of the relation of philosophy to science is contained in the instrumentalism of Professor Dewey. The main contention of this theory is that ideas are instrumental to action: they are secondary, derived *from* action, and they are teleological, dynamogenic, point forward *to* action; or, in so far as they win a permanent place for themselves as ideas, it is because they are more delicate types of action-systems. The reflective or mediating modes of experience are instrumental to the immediate forms of feeling and conduct.

It follows that the formal logic which was elaborated out of relation to the emotional and volitional needs of life, and is consequently correct only in so far as it remains abstract, and valid only in as much as it refers to nothing in particular in the world of concrete values—it follows that this logic will not meet the requirements of a scientific method which is seeking to explain the actual world of phenomena conditioned by human interests and purposes.

Instrumentalism, in other words, is an attempt at once to make philosophy scientific and science philosophic, and pragmatism means instrumentalism in this sense. In seeking to work out this relation in detail, pragmatism has become a general theory of experience, and, interpreted in terms of existing schools of thought, may be described as presenting both an empiricistic and an idealistic phase of its methodology.

In the first place, pragmatism is empiricistic. If philosophy is to be practical and personal and instrumental it must begin with concrete experience, not with an assumed reality beyond nor with an abstracted aspect. It must begin with the full tide of life as we live it and try to understand it from within, not seek to leap out of experience to some transcendental vantage-ground from which the procession might be watched from without. Nor will philosophy begin with such partial aspects as mind and matter nor with such terminal problems as origin and destiny, but will endeavor by a patient study of the way in which experience goes on in the present moment of consciousness to construct the law of the process by which it goes on in other moments. This is the empircal principle of pragmatism. As Professor Dewey puts it, Reality *is* what it is *experienced as*. Or as Hegel long since phrased it, "the laws of thought are the laws of things."

This empirical point of view has several important implications. It implies, for one thing, that the distinction between experience and reality is not an absolute one, not an ontological distinction, as the metaphysicians say, but only a methodological or functional one. It no more represents a distinctness in existence than does the distinction of the how and the what of anything, or the distinction of process and content. Experience regarded from the point of view of what it *is*, its content, its filling of objects and events, we call reality. Reality, regarded from the point of view of *how it goes on* or the way in which it occurs in consciousness, that is, viewed as a process of evolution here and now, we call experience. A moment of consciousness is a sample of how reality evolves. An object in space or an event in time is a sample of the content of this evolving process. Reality viewed in longitudinal section as a process gives us what we call experience. Experience taken in cross-section yields a content which we call reality.

In the second place, mind or consciousness *is* what it *seems to be*—a transformation-phase of experience, not a separate entity. The distinction of mind and body and their alleged disparateness and supposed parallelism is a pseudo-problem created by the methodological inutilities of a prejudiced metaphysics. Just as the hypostatizing of the distinction of reality and experience gave rise to the tedious detour of the epistemological problem, so the erection of the practical distinction between the psychical and the physical into an ontological chasm has produced the paradox of mind and matter in metaphysics. Aristotle's doctrine of entelechy was nearer the truth, which sought to define what a thing *is* in terms of what it *does,* in terms of its behavior and functions, and in terms of how it came to be what it is, its genesis and growth. Consciousness, the mind, the soul, is to be defined as a physical object is defined in science: a molecule or an atom is defined in modern physics as the sum of its attributes, the synthesis of the relations in which it stands. Consciousness no longer may be regarded as an entity, nor as the attribute of epiphenomenal manifestation of an entity; it must be defined, as everything else in modern science, as a relation or system of relationships. Reality, Lotze said, means standing-in-relations, a thing *is* where it *acts,* being is doing. If this is true, then consciousness is what it seems to be—a transition phase of the contents of experience under certain conditions in which they are undergoing reconstruction into something else. It is not a different kind of reality nor a permanent parallel aspect of material existence, but a mode of experience in the phase of metamorphosis into further experience.

A third implication of this pragmatic empiricism concerns our relation to the making of reality. There is a sense in which reality is *given* and a sense in which it is *made.* As Mr. Schiller says, you may "find yourself in love" or you may "make love." You may wish for a chair and find one or have one given to you, or you may wish for a chair and invent one, make one. Is reality discovered or created by knowledge? Are the objects which form the content of experience revealed or constituted by consciousness? This is one of the age-old problems of philosophy which have divided thinkers into transcendentalists and empiricists, nativists and evolutionists. Taking the two terms of the distinction abstractly, it seems that in the final analysis something must be absolutely given, on the one hand, yet, on the other, that something is absolutely created. It appears that there is nothing new under the sun, and yet that everything changes. If all is given, then the apparent progress and freshness of our feelings is an illusion, and if any single part of experience is absolutely given, the whole must be given, as the absolute idealists have been logical enough to see. On the other hand, if all is created, what is to save us from solipsism? The answer is, that neither term of the distinction is to be taken abstractly. *Given* means *taken as given* for the situation, while *made* or created means produced anew *relative to some interest* or need, not created *ex nihilo.* Our givings and takings, our acquiescences and imperatives, are not ultimate and abstract, but relative in the sense of relevant to the proximate needs of concrete issues. Taken abstractly, these complementary principles have significance only as limiting concepts, like the infinite and the infinitesimal in mathematics; they are signs of operations to be performed, not absolute realities blocking progress. There is no experience in general or in the abstract, no absolute experience; experience is always in specific centers of concrete interest and value. Hence questions of the absolute origin or absolute givenness of reality are unintelligible because irrelevant. We participate in the evolution of reality by every moment of conscious experience. The truth hasn't all happened yet, as Professor James says. Kant was right in a sense when he said that the understanding creates the world. But it is equally true that for any particular individual and for any particular moment of conscious experience, the high-lights of attentional consciousness are set over against a background of what, for the situation, must be taken as given—and this is the truth the metaphysical realists have built into a wall of separation between a subjective and an objective world.

These are some of the implications of the pragmatic philosophy as a doctrine of empiricism. But we maintained that it likewise represents a form of idealism, and that this is not only consistent with, but absolutely indispensable to the integrity of the empirical side of its method.

The pragmatic philosophy, by virtue of the fact that it purports to be a *philosophy*, is a form of idealism. All philosophies are idealistic in the deepest sense of the word—they are simply developed ideas of the universe. Pragmatic idealism is only a closer-knit synthesis of practise and theory than other forms of philosophy. If we define idealism as any philosophy which finds the key to the nature of reality in ideas, then pragmatism is a form of idealism, since it is itself a theory, an idea, a conception, a philosophy of experience. There is no necessary antagonism between pragmatism and idealism, since there is no necessary conflict between practise and theory. Pragmatism is not opposed to theory, but only to bad theory; it is not opposed to ideas, but only to ideas that do not work in practise; it is not opposed to ideals, but only to ideals that do not stand in organic relation to life.

The idealistic phase of pragmatism is to be found in its theory of knowledge, in its doctrine of the relation of ideas to action. Thinking, it holds, *is* action in process of transformation into more adequate action; the pragmatic philosophy is only human action or practise passing into the idea or theory phase for the sake of evolving a more adequate practise. Whether pragmatism is idealistic in either of the other two historically important senses of the word, which hold respectively that ultimate reality is mental (metaphysical idealism) and that the objective world has no existence independent of a knowing subject (epistemological idealism), is easily answered: it is not. These forms of idealism, as Mr. Schiller and Professor James and Professor Dewey in their different ways have shown us, are simply methodological circumlocutions produced by the interposition of false issues by an aprioristic preconception.

As long as men stop their practise now and again to think, they will be idealists. As long as the process of experience is more than a mere blind rule-of-thumb accidental fumbling or slow learning by the method of trial and error, as long as human progress takes place by experiment and invention as well as by repetition and imitation, the philosophy of experience must in the deepest sense of the word be idealistic. Ideas are not copies of realities beyond experience, but are certain contents which, because of their inadequacy, are undergoing revision in that mode of consciousness which we call knowledge: and consciousness and cognition are simply names for reality when thus undergoing reorganization from within. Ideas, as Professor Dewey says, looked at negatively and in relation to the practise which is breaking down, are simply facts which have come under suspicion. Thus we say that the sun-going-around-the-earth is a mere idea because it has become doubted: we call it an illusion. Looked at positively, in relation to further practise, an idea is a plan of action; it is one part of experience used as a means of getting further experience. There is no chasm between the world of things and the world of thoughts; the world of thoughts *is* the world of things viewed *in process* of becoming something different from what they have been in relation to the needs of former practise. From this point of view there is no need for a timeless, processless, inscrutable absolute to guarantee the integrity of a subjective-objective, mind-matter, ego-alter world: the only absolute required is the concrete process of experience itself. There is no absolutely absolute absolute just as there is no absolutely relative relative. Absolute idealism and absolute scepticism are self-contradictory limiting conceptions, neither of which is true, taken by itself, but each of which is useful in refuting the other by throwing it back upon the concrete process whence it was derived and where alone it is significant.

Quite the most delightful humor of the present philosophical situation is the way in which the pragmatists in practise repudiate pragmatism as a theory, while on the other hand the pragmatic theorists fail to see their own incorrigible idealism. Rotund in the complacency with which they regard their abstract ideals, which they sentimentally revere, but never use, the actual pragmatist looks with contempt upon the theory of his own practise when some ingenuous idealist seeks to formulate it for him. For what is pragmatic theory to him who is a pragmatist in conduct? It is heresy, blasphemy, anarchy—destruction of established ideals which must be protected at all hazards from any pollution by the "given case." He does not realize that he is destroying the only theoretically sound basis of his own practise, that his so-called ideals are simply masks to conceal the irregularity and irrationality of his practise.

But the full humor of the situation does not appear until we turn to the supposed teachers of pragmatism—the pragmatists in theory. They are not really pragmatists, most of them, but idealists. They have developed pragmatism simply as a means of realizing a new idea in philosophy which seems more valuable to them than any of the old ideals. The fact that the new ideal is not consciously present or clearly worked out, does not alter the case. The function of the philosophical pragmatist of the day is not to supplant the various forms of idealism which have held sway, but to make their ideals operative as forces in the world of actual conditions and causes. It brings ideals down to earth; it does not destroy them. The positive mission of the pragmatic theorist is to show men how to use ideals as genuine dynamic functional realities instead of sentimentally worshipping them in their inviolable isolation. Pragmatism means, not the opportunism or expediency philosophy which too often is the only working theory of the man of affairs; it finds the ideal *in* the conditions, cultivates and guides its growth *within* the given case, and formulates it by reading off the "law of the process" by which those very conditions have given rise to the given case.

Men can not get along, and remain civilized, without ideals. It is not only the lover, idolizing the object of his affection, who is actuated by ideals: the successful statesman, scientist or man of business is always an idealist. He has an insight and an outlook—a point of view—which transforms the world of facts in the midst of which he lives, from a brute mass of obstruction and baffling perplexity into a systematic scheme or plan for bringing things to pass. His scheme may be false in certain particulars, but he can no more get along without some centralizing intellectual machinery than a complex organism can get along without a central nervous system or a complex civilization without its methods of communication.

Ideals are simply codes, customs, institutions, habits undergoing reconstruction in the medium of the direct emotional appreciation and rational insight of individuals. A philosophy must at bottom be an idealism because it is a theory of human progress—it seeks to deal in idea methodically with all the conditions by which man evolves an increasingly enriched experience. But experience is not thus mediated when certain standards, relevant in some past situation, are carried over bodily and unrevised into new conditions. This is the fallacy of most of the rationalistic and absolutistic forms of idealism which have held sway. Accepted types of thought and action are imposed on a new situation, and where the new conditions do not fit the rigid framework of the old standard, effort is made to force them into conformity with it. This is the obstructive aspect of absolutism against which pragmatism has raised its timely protest and its demand that *all* the factors of a situation must be represented *constructively* in the result.

The pragmatic philosophy, in other words, is a functional idealism: its method is at once intrinsic or immanent and functional or organic. By saying that its method is immanent, we mean that experience must be interpreted from within. We can not jump out of our skins, as Professor James says; we can not pull ourselves up by our own bootstraps. We find ourselves in mid-stream of the Niagara of experience and may define what it is only by working back and forth within the current. "We don't know where we're going but we're on the way." If it be asked, Where does this "concrete" experience come from? the question, as Professor Dewey replies, is irrelevant. Experience does not "come from" anywhere. It *is* here. We begin with it as the reality-here-and-now. To pursue the question of the origin of experience in an absolute sense, is to seek to run out on an abstraction as if it were a tight-rope, when it has no support at the other end. "How experience became we shall never find out," writes Professor Dewey, "for the reason that experience always is. We shall never account for it by referring it to something else, for 'something else' is only for and in experience." Or, as Professor James has put it, "Though one part of our experience may lean upon another part to make it what it is in any one of several aspects in which it may be conceived, experience as a whole is self-containing and leans on nothing."

By organic or functional is meant that all distinctions in theory are true only in relation to the specific situation within which they are set up. There is no truth in general or in the abstract: there are only truths. It further means that in the case of all the dualisms of reflective thought which have occasioned so much controversy in the history of philosophy, each abstract member of the dichotomous distinction is true only in relation to the other. Does a man walk more with his left or with his right leg? asks Professor James. If he is lost in the forest in the northern hemisphere, he may be said perhaps to walk more with his right leg when he goes around in a circle to the left, but more important than the fact of inequality is the fact that he must use them both and that they must cooperate to a common end, if he is to be said to walk at all. When I follow the squirrel around the tree, do I or do I not go around the squirrel? As Professor James here, too, has pointed out, I do, and I do not, go around the squirrel according to which situation of "going around" is under discussion. As he continues, it is not particularly illuminating when you ask what o'clock it is, to be told, as the traditional metaphysician tells us, that he lives in Kensington Place.

Only by a functional interpretation of the time-honored antinomies of reflective thought is it possible to put any practical meaning into the dualisms of actual and ideal, finite and infinite, one and the many, subject and object, mind and matter, ego and alter, reason and faith, good and evil, right and wrong, experience and reality, and the host of other antitheses which the dialectical ingenuity of sapient man has teased out of the intricate meshwork and living tissue of concrete experience.

In conclusion it should be said that, just because pragmatism is idealistic, it is not egoistic, as it has been falsely charged with being, in either the social or the ethical sense.

One of the main contentions of the pragmatists who have been quoted in the foregoing paragraphs, especially of Professor Dewey, who is its most consistent exponent on this side, is the social conditioning of consciousness and of the knowledge process by which reality is constituted in experience. This is not the place to expand upon it, but it is important to note that for the pragmatic idealist, consciousness is essentially social in its content, individuals are functions of each other, selfhood is achieved only through interaction of selves; and cognition, which is ordinarily conceived as a mental process going on in the head of some so-called individual, is a process which includes the object as well as the subject in its activity. As Professor Royce has so ably set forth, the external world is the communicable world, is socially constructed, and it may with truth be said, as a recent writer expresses it, that it is as proper to call ultimate reality a society-of-selves as to call it the absolute.

The pragmatic ethics is currently described as the art of making one's self comfortable in the long run, or, in its more cynical form, if you can't have what you want, don't want it. The reply to the implied criticism in the first formulation is that egoism is not incompatible with altruism. It is true, not only that what is good for society is good for the individual, but that what is good for the individual must in the long run be good for society. Egoism or individualism in a functional sense, which recognizes the relationship of the self to the social whole, is the very essence of progress. Egoism and altruism, like other abstractions, when taken in isolation, confute each other. An altruism which is only an excuse for trying to manage other people's affairs is not different from a self-centered egoism; while an egoism which conceives of the self so widely and so generously that it can not find happiness save through the happiness of others, is a very genuine kind of altruism. And the alternative suggested in the second formulation of the pragmatic morality is not the only one: another would be: If you can't have what you want, want it more vitally, more organically, until you get it. A pragmatic ethics refuses to believe that any craving or impulse of human nature is bad as such. There is no absolute evil. Error and evil, like truth and good, are matters of relationship; and, just as the truth is not attained until all the so-called errors are seen in relation to each other and to the whole as partial truths, so all the so-called evil impulses of man must be represented constructively in that outcome of the moral struggle which we call the good. "Nothing succeeds like success," "It's true if it works," are phrases which are capable of an idealistic interpretation in relation to social progress as well as of an egoistic and ethically materialistic interpretation which results in anarchy.

Life is a game of skill, and pragmatism is an attempt to "play the game" as well as possible, since perforce we must play it. It *is* a philosophy of work, of practise, of labor, of the strenuous life; but it is not simply that. Since, as we have seen, it is not mere practise, but likewise a theory of practise, this brings in the other side which we have called its idealistic aspect. But pragmatism is more than either an empiricism or an idealism: it is an immediatism or mysticism in the good sense of the word—it is a philosophy of play and a branch of fine art. It provides for moral holidays; it is a philosophy of that culture which in its leisure is not idle; it finds a place for the feelings and values and ends of life as well as for conduct and ideas and the means of living. The simple life is as truly its goal as the strenuous life! The simple life!—the "last refuge of complexity!" How much effort people put forth in the endeavor to lead the simple life! It is not getting away from complexity, but controlling complexity in relation to the attainment of the values of life, that pragmatism recommends—not the simple life, but the simplified life. And among other means of the control of cultured living, a true philosophy finds its place: first, as a balance-wheel to the tangential tendencies of lopsided common sense with its uncommon stupidities and rigidities and foreshortening of view; second, as a clearing-house for balancing up the credit and debit accounts of science in relation to this great problem of the control of the conditions of living; and third, as an enhancement of the appreciation of the values of life in emotional and personal terms, by seeing all knowledge and conduct in their widest cosmic and deepest spiritual implications, and feeling with Kant and Tennyson the relation of the flower in the crannied wall of one's own door-yard to the stars above and the moral law within. This is pragmatism and this is a philosophy which must recommend itself to men and women of to-day.

THE MOVEMENT TOWARDS "PHYSIOLOGICAL" PSYCHOLOGY. II

By Professor R. M. Wenley
University of Michigan

IV

THIS brings us at length to the true physiological line, and to the rapid assimilation of psychology to positive science. The starting point lies in that French group whom Napoleon nicknamed contemptuously, *les Idéologues:* Cabanis, de Tracy, Laromiguière, and Maine de Biran.[1] Cabanis and de Tracy were the leaders in all essentials. Their movement formed part of the mighty revolutionary upheaval. By analysis of sensations and ideas they proposed to discover a method of remoulding society, government and education for practical purposes. De Tracy (1754–1836) elaborated what Beneke would have termed the "inner" side of ideology. His noteworthy efforts lie in the fields of language, grammar and logic, of economics and government, of morals and education. Yet the influence of science upon him, as upon his fellows, produced results that should receive notice here. He anticipated Comte in the view that knowledge, properly so called, consists in an organized system of the sciences; "positive science," as he declares, and to him, more than to Comte and his pupils, we owe this term, now beatified. In the second place, and coming to the physiological reference, he was the first to recognize the importance of muscular activity as a factor in consciousness.[2] This formed his point of contact with Cabanis, who studied what Beneke would have called the "outer"—the physiological accompaniments of psychological processes.

Cabanis (1757–1808) inherited the English sensational tendencies represented in France by Condillac, but he added that acquaintance with the human body which he acquired as a physician. In his person the philosophical and physiological lines coincided. His principal work, "Rapports du Physique et du Morale de l'Homme," grew out of a series of papers read before the French Institute and published in its proceedings for 1798–99. So far as he possessed any consistent philosophical standpoint, Cabanis was a pantheist (and, in speculative physiology, therefore, a vitalist), as his posthumous "Lettres sur les Causes premières" (1824) and his discussion of the Stoics in the

[1] Cf. "Les Idéologues," Fr. Picavet (1891).
[2] *Ibid.*, pp. 377, 337 f.

"Rapports" show. Nevertheless, later materialists find warrant for their most striking metaphor in his pages. As the liver secretes bile and the kidneys urine, so the brain secretes thought; thus ran Karl Vogt's raucous challenge (1847). Cabanis employed the very phrase "secretion of thought" which, as his editor, Peisse, says, "has remained celebrated." But the classical passage, also in the "Rapports," reads as follows: "In order to arrive at a correct idea of those operations from which thought arises, we must consider the brain as a particular organ, destined specially to produce it in the same way as the stomach and the intestines are there to perform digestion, the liver to filter the bile, the parotid, maxillary and sublingual glands to prepare the salivary juice."[3] This is the clear summons to a physiological psychology. Very naturally, Cabanis aimed to supply what Condillac omitted. Condillac's sensationalism, like that of the English school, found basis in the external senses. It therefore missed those organic and internal changes which physiology alone could set forth. Cabanis, accordingly, insisted that multitudes of impressions proceed continually from the internal organs to the brain, and that the conditions of the cerebro-spinal system form a determining factor in this process. Or, to be more emphatic, as it continues to maintain its unstable equilibrium, the organism originates *vital feelings within itself*—feelings that bear no direct reference to the external world. That is, the impressions of Locke and Hume do not play upon a *tabula rasa,* but are met, and twisted, by these organic feelings. The unconscious joins up with the conscious. Of this process instinct offers a conspicuous example. Here, primordial experiences, traceable to the embryo, provide a foundation of organic sensation which (in the light of the doctrine of evolution) would explain away psychological processes as automatic—as epiphenomena of the bodily substrate. In this respect Cabanis was a prophet. Nevertheless, despite his studies of age, sex, temperament, sensibility, irritability, habit, climate, the fœtus and instinct, he fails to work through his great theme with the necessary grasp upon detail. His epoch would not let him. Yet he saw the promised land afar off. For, to him, psychology was already a natural science. It traffics with phenomena, never with metaphysical realities, and its material must be found in the relation of mental states to physiological conditions. Hampered everywhere by contemporary ignorance of nervous anatomy, he still contrived to formulate a vivid and convincing psycho-physiological *schema,* for which, we may as well confess, due praise has never reached him. Physiology passed to another land, and he fell into an oblivion rather discreditable to the historical insight of those who came to elaborate his anticipations.

Plainly a physiological psychology can not emerge in absence of a

[3] Œuvres, Vol. III., p. 159.

physiology. The numerous accessions of physiological knowledge during the last seventy years tend to obscure the unpropitious outlook at the dawn of the period. Referring to the time (1841) when he became *préparateur* to his distinguished predecessor, Magendie, at the Collège de France, Claude Bernard drew a gloomy picture.[4] The established "natural history" sciences—geology, botany, zoology—possessed fair equipment, particularly on the museum side. While chemistry, thanks doubtless, to Liebig's activity at Giessen, made rapid strides. But physiology enjoyed no such advantages, was opposed, indeed, even by a genius of the calibre of Cuvier. "So soon as an experimental physiologist was discovered he was denounced; he was given over to the reproaches of his neighbors and subjected to annoyances by the police."[5] Sir Charles Bell had intimated the contrasted functions of the anterior and posterior roots of the spinal nerves (1807), but had given no experimental proof: and Marshall Hall (1835) had discovered the reflex function of the spinal cord. But no group of investigators had arisen such as was to place Germany in the leadership. Her preeminence, unchallenged still for physiological psychology, dates from the life-work of Johannes Müller, and his profound influence, especially at Berlin, from 1833 till his death in the year before "The Origin of Species" (1859).

At this date the intellectual condition of Germany may be called unprecedented without exaggeration. And the fate reserved for unique things has overtaken it. Later men, particularly on the scientific side, have heaped on it multiplied misunderstanding or even obloquy. Little as I cling to them, I am compelled to declare that Schelling and Hegel were no day-dreamers, evolving camels from their inner self-consciousness. Both were great men, and Hegel takes his place among the few marvellous intellects of history. But both suffered from their very success. Hegel's philosophy formed the seedplot of that comparative and critical *Wissenschaft* for which human history supplies the material. As these disciplines developed, the defects of the Hegelian system became more and more irremediable. Yet, the system lacking, the sciences could not have come to birth. Schelling stood in similar case. German science from 1797, the year of the publication of his "Ideen zur einer Philosophie der Natur." till 1830 or thereby, drew inspiration from his humane, if vaulting, spirit. Alex. von Humboldt, as his biographer Bruhns points out, attempted "by means of a comprehensive collation of details, and the institution of the most searching comparisons, to give a scientific foundation to the ideal cosmology of Herder, Goethe, Schelling and their disciples." Further, Schelling stimulated Carus, the comparative anatomist: Oersted, the father of

[4] Cf. "Physiologie générale," p. 203.

[5] *Ibid.*, *l. c.*

electro-magnetism; Kielmeyer, an anticipator of biogenesis; I. Döllinger, of Würzburg, who inoculated Von Baer with genetic ideas; Von Baer himself, who, more objectively than any other scientific man, has estimated the *germinal* significance of the *Naturphilosophie;* Liebig, the pioneer of laboratory methods in chemistry; Johannes Müller, the first main constructive power in modern physiology; Kieser, the early exponent of plant phytotemy; Schönlein and Röschlaub, leaders in the remarkable band who founded the Berlin school of medicine. Nay more, his power burst forth again, significantly for psychology, as a factor in the equipment of Fechner. Thus, like Hegel, Schelling paved the way for his own fall, by sending others to search out the secrets of nature. Accordingly, even if the vagaries of Oken disgusted many,[6] and if Steffens's analogies between the catastrophies of the human spirit and the disturbrances of the earth's crust furnished queer geology, there were no call to "swear at large," to rush around shouting "vitalism!" or otherwise to evince complete lack of the objectivity necessary to analysis of the crisis. Somnambulists haunt the fringes of all movements, but we fool ourselves when we take them for prototypes. New ideas ever were heady; this happens to be the price set upon their power to reveal unsuspected problems, as Schelling and his galaxy of scholars did.

Johannes Müller, then, found himself born into this surging age. He tended the new scientific spirit to budding, but, unlike Von Baer, he died ere it blossomed. Speaking under reservation, as an ignorant man must, I would venture to suggest that he did not enter fully into Hegel's epoch-making idea of *process.* So far as I can comprehend his activity, he was a student chiefly of the organism in gross, that is, a morphologist, more than an investigator of vital processes, a physiologist. His importance lay in his ideals more than in his results. "A profound teacher," as his pupil Helmholtz declared, he created an atmosphere which his pupils breathed, and he lives in their splended work rather than in any single achievement of his own. In essentials this atmosphere contained the modern perspective. For, although, as du Bois Reymond has recorded, he "assumed the existence of a vital force . . . which in organisms acts the part of a supreme regulator," this "force" ruled the realm of the unknown only. In all that could be mastered by contemporary methods and means Müller accepted the chemico-physical view. His studies of nutrition, animal heat, motion and reflex action, his contributions to acoustics and the phenomena of speech embody, not simply his own work, they also supply a masterly unification of previous knowledge. But, especially as concerns physiological psychology, his major result undoubtedly consisted in his doctrine of "specific energies." No matter what the stimulus, the

[6] Cf. Huxley, in the "Life of Owen," Vol. II., p. 295.

same nerve always originates the same sensation. "Müller's law of the specific energies marks an advance of the greatest importance . . . and is, in a certain sense, the empirical exposition of the theoretical discussion of Kant on the nature of the intellectual process in the human mind."[7] Of course, Müller's views drew criticism,[8] but for us now *the* point is that they started activity which, bit by bit, built physiological psychology into a science.

Fortunate in his disciples—Brücke, Helmholtz, du Bois Reymond, Ludwig, Czermak, Donders (most teachers would forego all personal glory gladly to obtain such human material)—Müller enjoyed luck in the contemporary course of events. For a science more developed and surer of itself than physiology was about to join forces with the newer branch. Magnus, his Berlin colleague in physics, became the focal point of a movement to which Mitscherlich, Liebig, Ohm, F. Neumann, and the brothers Weber all contributed, the first and last notably. The sobering drill of hard, experimental fact gained its recognition here. Or, as we say in philosophy, the prose of Kant was added to the romance of Schelling. For physiological psychology the steadying influence came most by way of Ernst Heinrich Weber, of Leipzig (1795–1878). Weber, with his younger brothers, Wilhelm and Eduard, worked from the first along distinctively modern lines. The speculative thought, prevalent in his youth, seems to have passed over his head. Exact experimental methods came naturally, as it were, to him and to his brothers. From early life they employed mechanical and mathematical analyses in dealing with physical, physiological and psychological phenomena. Kunze, Fechner's nephew and biographer, goes so far as to say, "they were among the first to raise the study of nature among Germans to the eminence occupied by the philosophers and discoveries of the Latin races."[9] Their first joint research is typical of this. In the "Wellenslehre auf Experimente begründet" they add to Chladni's acoustic theory a parallel account for light, which leads substantially to the inference of an elastic ether. Prior to this Weber had published researches on the "Comparative Anatomy of the Sympathetic Nerves" (1817) and "On the Ear and Hearing in Men and Animals" (1827). His psychological contributions appeared in Wagner's "Handwörterbuch der Physiologie," Vol. III., part 2 (1831), and in the "Archiv für anatomische Physiologie" (1835). The classical paper, "Tastsinn und Gemeingefühl," was printed in the former and published separately in 1851. Weber here applied the method of least observable differences to sensations of pressure and to the measurement of lines by the eye. These experiments resulted in

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[7] "Physiol. Optik," Helmholtz, p. 249.

[8] Cf. *Mind*, V., pp. 1 ff. (old series).

[9] "Gustav Theodor Fechner (Dr. Mises): Ein deutsches Gelehrtenleben," p. 243.

the generalization to which the name "Weber's Law," or the "Fechner-Weber Law," or the "Psycho-physical Law," has been given. Referring to this discovery, in the preface to the first great book on physiological psychology, Fechner affirms: "The empirical law which forms the principal foundation, was laid down long ago by different students in different branches, and was expressed with comparative generality by E. H. Weber, whom I would call the father of psycho-physics."[10] The law summarizes mathematically the relation between physiological stimulus and psychical sense-perception. It is based on the fact, familiar in common experience, and now authenticated by numerous observations and experiments, that the difference between two sensations bears no direct proportion to the actual difference between their stimuli. Granted that the least observable difference be a constant, then, the strength of sensations does not grow in proportion to stimulus, but much more slowly. Weber's experiments were directed towards measuring the *exact* proportions, and involved comparisons of lines by the eye, of weights and of tones. The resultant generalization has been formulated in various ways. The most direct are as follows: "In order that the intensity of a sensation may increase in arithmetical progression, the stimulus must increase in geometrical progression"; or, as put more briefly by Fechner, "the sensation increases as the logarithm of the stimulus"; or, as Delboeuf has it, "the smallest perceptible difference between two excitations of the same nature is always due to a real difference which grows proportionately to the excitations themselves." Like all laws, so-called, this one is an abstraction from experience. Consequently, it has been subjected to various interpretations, has been transformed and criticized, and even denied. Again, like all laws, so-called (*e. g.*, Boyle's law), it holds good only within limits, and round this aspect of the matter multitudinous experiments cluster. Space forbids more than a reference to easily accessible literature.[11] Whatever psychological experts may consider to be the present status of the conclusion, Weber's withers are unwrung. His crowning achievement was to have shown that measurements and mathematical methods *can* be applied in this region of experience. He thus served himself the founder of the Leipzig line, the torch passing from him to Lotze, to Fechner, and finally to Wundt.

As at the beginning of modern European thought, in Descartes, Spinoza, and Leibniz, so here in the Leipzig men, philosophical insight

[10] "Elemente der Psychophysik," preface, p. v.

[11] "German Psychology of To-day," Th. Ribot (where Delboeuf's researches are given). "The Human Mind," Sully, Vol. I.; article "Weber's Law" in the "Encyc. Britannica"; "Principles of Psychology," Wm. James, Vol. I. (a most unfavorable critique); "Elements of Physiological Psychology," Ladd; "Human and Animal Psychology," Wundt, Lectures II., III. and IV.; "Outlines of Psychology," Külpe.

and power were joined to scientific competence. I, therefore, leave them for a moment to take a glimpse—it can be no more—at the strictly scientific interest as we see it illustrated in Johannes Müller's greatest pupil, Helmholtz (1821–1894).

Helmholtz ranks not simply with the foremost scientific intellects of the nineteenth century but with the master minds of all time. His range, grasp and insight combined to render him monumental. A contributor to at least eight sciences—physics, physiology, mathematical physics, meteorology, medicine, chemistry, anatomy and esthetics, in three of them he stands high among the foremost. More than this, as Volkmann has recalled, "one of his chief merits was to establish a harmony between the vast accumulation of facts that characterized the period comprehending the middle of this century and the more theoretical studies." [12] Besides, he possessed unusual manipulative skill, his inventions of the ophthalmoscope and ophthalmometer alone would have assured any ordinary reputation. Above all, he was a humanist, being an accomplished musician, an art critic, and acquainted with the trend of philosophical thought. His discoveries of classical grade amaze one by their thoroughness and versatility. The conservation of energy; the mechanism of the lens of the eye in relation to accommodation; the movements of the eyeballs with the attendant problems of binocular and stereoscopic vision; the profoundest questions of hydrodynamics, thermodynamics and electrodynamics, the last culminating in the revelations of his favorite pupil, Heinrich Hertz; the axioms of geometry; the dark places of meteorology; the deeps of physiological optics and of mathematical physics, all bear witness to his profound, masculine and subtle intellect. But, for our present study, the palm must go to his long struggle with the difficulties of sensation and perception. These absorbed his principal attention from 1852 till 1867 and, in a lesser degree, till his death. He laid the foundation characteristically by his inquiries into the rate of nervous impulse in the motor and sensory nerves, about 1850, and his first paper, on sensation proper, followed in 1852. These labors were crowned magnificently by the publication, in 1863, of his "Sensations of Tone," and, in 1867, of his "Physiological Optics"—masterpieces both. The former, which involved the most complicated research, has earned the title, "the *Principia* of acoustics," and must be studied long to be appreciated. For, it not only ranged over the entire subject but, incidentally, raised important problems that belong elsewhere, especially to the domains of phonology and esthetics. Questions about the quality of the human voice and the absolute pitch of vowel sounds lead us away from the physical and the physiological laboratory to a very different environment. Similarly, the "Physiological Optics," with

[12] "Hermann v. Helmholtz," J. G. McKendrick, p. 284.

the Young-Helmholtz theory of color, presents investigations about which psychologists are bound to trouble for many a day.

Thus, the significance of Helmholtz's career may be traced to his combination of the mathematical and exact-scientific with the humanistic interest, a union to which we may attribute our greatest advances alike in science and in intellectual insight. And this fitted him rarely to execute work of abiding value for physiological psychology. No one has contrived to reach better results in those unplumbed reaches of experience where the joint action of body and mind can be studied with a measure of success. Proceeding from the theory of "specific energy" of his master Müller, he wrought it out in detail, eminently for the mechanism of sight and hearing, by experimental methods and by mathematico-physical analyses. Upon the romantic interest in nature stimulated by Schelling he superimposed the critical processes of Kant, armed with all the resources of the most delicate apparatus and rigid analytic procedure. This coalition of endowment and outlook continued in the three leaders who were destined to build psychology into an independent science—Lotze, Fechner and Wundt. To them we shall turn next.

A PHYSIOLOGICAL PROBLEM: ENZYMES

By ORVILLE HARRY BROWN, Ph.D., M.D.
PHYSICIAN IN CHIEF OF THE MISSOURI STATE SANATORIUM FOR INCIPIENT TUBERCULOSIS
MT. VERNON, MO.

THE question of enzymes is one of fascinating interest to the biologist. There is more or less of a mystical atmosphere surrounding these unknown ever-present bodies in all living organisms, on account of the difficulty in effecting their isolation, and in regard to the method in which they perform their function. The study of enzymes has been pursued with much vigor for years by eminent investigators of the biological sciences, and yet their exact nature is almost as little understood to-day as ever. No enzyme has been absolutely isolated, and consequently the chemical constitution of these principles is yet a matter of conjecture. We can, however, unerringly detect their presence, both qualitatively and quantitatively.

The terms enzyme and ferment as used to-day are practically synonymous. The latter term is doubtless the more familiar of the two to the laity. A classical example of fermentation is the changing of sugar, by means of yeast, to alcohol and carbonic acid gas. The yeast is necessary to this process, in so far as it elaborates the active agent—enzyme, or ferment—which is essential. The yeast, more properly according to our former conception, than now, is spoken of as an organized ferment. This was on account of the supposition that the yeast itself was the ferment. It has only recently been shown that a substance can be extracted from the yeast cell, which brings about the process, spoken of as fermentation. In contradistinction to the organized ferments there were the unorganized ferments, as, for example, the enzymes of the alimentary canal, which were capable of bringing about digestion as well outside of the body in a test beaker, as in their normal habitat, the stomach and intestines. The separation of a material from the yeast cell, which still possessed its activity made obsolete the classification of unorganized and organized ferments. The agents which were formerly classified under the two heads, although differing in characteristics, are alike in that both are definite chemical substances secreted or manufactured by cells—a single-celled organism in one case and a multicellular in the other. Many bacteria were formerly believed to belong to the same class as the yeast, and thought to possess a fermentative function; now it is known that the bacteria elaborate a substance which has the enzymotic properties.

The physiologist defines an enzyme as a body, which, remaining unaltered itself, accelerates a chemical reaction, otherwise going on very slowly. To elucidate with an example: fat is a chemical union of two compounds, one of which is called a fatty acid, and the other an alcohol. Fat, in the absence of a fat splitting enzyme, yields very small quantities of these two substances in the course of a long time. But, in the presence of a proper enzyme the fat yields considerable quantities of fatty acid and alcohol in a comparatively short time. The rapidity of the splitting is directly proportional to the amount of the enzyme added. A small amount of the enzyme will decompose just as much of the fat as a large quantity will, but a longer period of time is required. A quantity of the enzyme may be used over and over again for splitting any amount of fat, unless it is destroyed by bacteria, heat, chemicals, or some other deleterious agent.

When fat and an enzyme are placed in a test tube together, not all the fat is changed into its component parts. The reaction proceeds until more than half the fat is decomposed. Then there is a reversal of the chemical reaction. Fat is reformed from the fatty acid and alcohol; the splitting process proceeds very slowly if at all. The fat formation goes on as the predominant process in the tube until an excess of fat is formed, when a reversal again occurs, and fat decomposition becomes the chief reaction in the test tube. The alternate breaking down and building up goes on indefinitely, like the swinging back and forth of a pendulum. The sweep of the pendulum when first started may be broad, but if allowed to swing uninterruptedly, there is a gradual diminution of the distance traversed until the pendulum eventually comes to a standstill. Thus it is with the chemical reaction. This power of an enzyme to carry a chemical reaction in either direction is spoken of as the reversibility of enzymes. This has not been demonstrated to be true of all these bodies, but the physiologist delights in the speculation that it is; and many are the problems planned to demonstrate this characteristic in this or that enzyme.

Enzymes have important functions to perform in both animal and plant economy. Practically all of the chemical reactions, normally occurring in life processes, are believed to be aided by ferments. The distribution of these bodies in an organism is general. In man they are found, not only in the alimentary canal, but in the blood and lymph and presumably every cell of the body. The ferments of the alimentary canal are there for the purpose of splitting the food stuffs into their components, which are more readily absorbable than the original materials. Those of the liquids and cells of the body reform and build up the food elements into the vital tissues or protoplasm of the organism.

Another process in which enzymes play an omnipotent part is that of respiration. The oxidation of the protoplasmic constituents, from which the heat and energy originate, and upon which life is so alarmingly dependent—going on, not chiefly in the lungs or blood, but in every cell of the body, is responsible to an enzyme, or catalase, known as an oxidase. The result of these elements, which is the bringing about of the union of oxygen with the tissue, is perfectly well known, but the chemical nature and the physical characteristics of the oxidases, are problems for speculation.

The enzymes in plant cells are similar at least in action to the corresponding ones of animals; but, in addition to those possessed by animals, plants have ferments which enable them, in the sunlight, to use carbonic acid gas in building up some of its cell constituents.

The method used in the laboratory for demonstrating the presence of an enzyme is very simple. The tissue to be examined is finely minced and ground up in a mortar. In order to facilitate the division of the cells, sand may be used in the grinding. The pulverized mass is then mixed with water or a dilute salt solution, which dissolves the enzyme. To find out what the nature of the enzyme may be, a small amount of the solution just prepared above, free of residue, is added to a solution of a substance, as starch, fat, or proteid, which an enzyme may decompose. After the course of a few hours the mixture is tested for the splitting products of the respective substance added. If such be found and none were in either solution when kept separate, it may be safely concluded that an enzyme has been discovered in the tissues examined. Very likely it can be demonstrated that the tissue contains more than one ferment, by showing that the tissue extract will split more than one class of substances.

It has been but recently discovered that enzymes or, better, proenzymes have an interaction. The pure secretion from the pancreas does not digest proteids. The unadulterated juices from the intestinal wall do not split up proteids. But a mixture of the two secretions possesses marked proteolytic powers. This phenomenon has also been observed with other ferments.

It has been known for years that certain finely divided metals, like silver, platinum, gold and others, possess the property of accelerating some of the reactions of, or chemical changes in, inorganic chemistry. As an example—if any one of the above metals be added to a solution of hydrogen dioxide, the compound is decomposed into its constituents, water and oxygen. It remained, however, till recent years for a young man working in the physiological laboratory of one of our great universities to show that these finely divided metals, elements of the inorganic world, could perform the function of a body ferment. Finely powdered platinum prepared by precipitation—known as platinum black—when added to a simple fat, decomposes it, in the same manner as a body enzyme would do. The metal has practically all the characteristics of an organic enzyme. It digests the fat; it rebuilds fat from the component parts, *i. e.*, its action is reversible; it is affected similarly by temperature changes and chemicals.

Another parallelism exists between the "vital" and inorganic phenomena, in the action of the salivary juice and acids on starch. The starch is to a greater or less extent digested in the mouth by virtue of a starch-splitting enzyme of the saliva. The same thing occurs if the starch and saliva are put together in a test tube. Acids will also digest starch. There is one marked difference, however, between the two. Enzymes act best at body temperature or a little above, while acids require boiling for their optimum action.

The temperature at which ferments act best is usually a little above the temperature of the body to which they belong. The optimum temperature for the action of enzymes of cold-blooded animals is below that for warm-blooded animals. A rise of twenty or thirty degrees above the optimum temperature destroys the ferments. A lowering of the temperature unless to the extreme does not kill; it only inhibits. The enzymes regain their function when the temperature returns to normal.

Many drugs have a very decided influence upon the fermentative processes. Of recent years this problem has occupied the mind and time of a number of physiologists. It is evident that this is a question of vital importance, on account of the general distribution of enzymes in the body, and the common introduction of drugs into the body. Very much too little is known, by even the scientific physician of to-day, regarding the action of drugs on the enzymes of the body. Some chemicals when present with the enzyme increase its power to do work; others decrease its power; and others stop it entirely. The concentration of the chemicals is of paramount importance. Most chemicals in concentrated solutions entirely prevent the action of ferments. On dilution the inhibitory power of the solutions decreases. In moderate concentrations some inhibit, more or less, and some stimulate, more or less. Both these processes usually decrease as the concentration of the respective solutions decrease. In some cases an effect may be noted in even very dilute solutions; a good example of such a solution is hydrocyanic acid.

If the author has been successful in the presentation of this subject, the reader should be impressed with the importance of the problem. The intimate relationship of enzymes with the vital processes renders an extensive knowledge of these bodies fundamental in the research into the phenomena of life.

NEEDED: A SYSTEM OF AQUATIC FARMING

By Professor HERBERT OSBORN

OHIO STATE UNIVERSITY

THERE is a natural resource available in many parts of the country, indeed, on a large number of farms or in larger unused tracts of the entire Atlantic and Mississippi Valley region, that is not only almost wholly neglected, but the neglect of which involves a number of phases of economic loss. This loss becomes more serious and the reparation the more difficult as time passes, and hence a note of warning and appeal seems justified.

The present tendency is to reduce not only all accessible forest areas to ordinary farm cultivation, but by drainage of all possible swamp areas to still further increase the area for ordinary tillage and to decrease those tracts which have in some degree the function of holding and regulating the outflow of our rainfall.

Without attempting to discuss all the economic problems connected with this phase of the subject, we may note that it affects the constancy of water level over considerable areas, the flow of streams with its bearings on flood disasters and navigation, but perhaps more vitally the carriage of fertility from the farming regions to the sea, where, if it ever becomes available as a human resource, it is so remotely advantageous to the farm or to the nation that it must be counted an economic loss.

The assumption seems to have been, based, doubtless, on our knowledge of but one kind of farming, that every bit of land not under ordinary farm culture was a loss, and therefore to be transformed as rapidly as possible to cultivated fields. To this end, forests have been felled, and lowland swamps and marshes, even including many extensive and valuable bodies of shallow water, have been drained. This means that instead of acting as natural reservoirs and conservators of moisture and fertility, their surplus moisture content has been discharged as rapidly as possible into the rivers and so on to the seas.

Before making some suggestions as to systems of farming by which it seems possible to avoid this waste, and, on the other hand, to develop some most productive sources of wealth, it will be in place to call attention to the capacity for production resident in every permanent body of water.

Every one is familiar with the rank growth of swamps and lowlands and the most superficial observation will reveal the enormous masses of plant life growing in bodies of still water, or even in running water where the bottom will permit the rooting of the plant. But in addition to this evident growth there is an enormous development of life, microscopic or transparent and invisible except when collected and studied by proper methods, which, in rapidity of growth and amount of mass may far outclass the visible portion. Some of this becomes apparent as green scum or as floating masses when its growth exceeds the capacity of the aquatic animals to consume it. Sometimes these minute algæ become a great source of annoyance in water supplies if for any reason their multiplication is unchecked, since they give offensive odors and taste to the water.

It has been estimated that the rate of development in some of these organisms is such that the possible progeny of one individual would suffice to fill all the waters of the globe in less than a week.

This is significant to us here simply as showing the enormous possibility of these organisms in utilizing water and air in the formation of vegetable substance, which substance may, with proper utilization, be transformed into fertilizing agents for the production of valuable plant crops or into animals having direct commercial value. To understand this process, let us consider for a moment the relations existing among aquatic organisms. The algæ may be considered among the more simple and these develop with only water and air or the other inorganic contents of water, but they furnish food for an innumerable host of microscopic animals such as amœbæ, rotifers, etc., and these in turn are fed upon by others, such as microscopic crustacea, which again form an important part in the diet of young fishes. These, when grown, or after furnishing the basis of food for other larger species, may reach our tables as human food. This, however, is but one line of transformation, as we have fishes of very different habits utilizing different kinds of aquatic life as food.

Where the life taken from the water does not balance the production, or where this product is not drained off into the sea, the accumulation of organic débris forms at the bottom a mass of richest organic matter, which by its decomposition may in a large part result in marsh gas, and in this form escape into the air.

Having indicated the possibility of an unworked phase of agriculture, or *aquaculture,* let us now turn to some of the possible lines of development in this field.

We have in America practically no established system of cropping our water areas. It is true that some progress has been made in the sponge farming of Florida, and oyster farming in Rhode Island, Connecticut, Virginia, North Carolina and Louisiana, but even these need further development to utilize the natural possibilities.

But so far as fresh-water culture goes, there is scarcely a beginning. Something has been accomplished in fish culture in some sections, but even here the full utilization of the resources of a body of water are but poorly accomplished. A few sporadic efforts have been made here and there in the culture of frogs and turtles, but how many of them with such attention to the subject as to warrant the term culture? In fact, these efforts have often resulted in failure and their projectors looked upon as visionaries, worthy the contempt of the hero in the "Virginian."

The farmer who drains and cultivates an acre of swampy land on his farm gains that much additional space for his ordinary culture and for a time at least it may be unusually productive as it contains the accumulated organic débris of years, but would it not be far greater wisdom to dredge out occasionally a portion of this accumulation to spread upon the higher ground and keep the acre as a source of fertilizing material for the years to come. This seems all the more desirable when it is remembered that this basin must collect quantities of the finest and most fertile parts of the soil washed from the higher ground. Moreover, I hope to show that there is good reason to expect that the acre can be made so productive over and above this function of conserving fertility that it will be worth more in water than it could be as cultivated land.

What is needed in the matter of utilization of our great tracts of marshy or swampy land is some such systematic study and the development of some such adapted system as is in progress of development in the systems of "dry farming" in the arid or semi-arid regions of the west—a system which will intelligently conserve and utilize our heritage of water, not throw it ignorantly away and reduce our uplands to a condition of sterility.

Frog farms, turtle farms, fish farms by themselves might be put in the same category as skunk farms and fox farms: useful to utilize certain minor tracts of otherwise worthless land, but what is needed, if any general good is to follow, is a rational system applicable to the treatment of all tracts of level swampy land, especially those at the head waters of the great river systems and in the coastal swamps of the Great Lakes and river deltas—in fact, to all areas where a fairly constant water level is possible.

Possible Crops

It is evident that in the nature of things wherever private ownership exists, or is possible, the effort inevitably will be toward gaining the largest immediate return from any such area, and the only hope of preserving these swampy tracts as reservoirs of water will be to hold them as public reservations or to devise some system of production which will make them more profitable with the water retained than they can be with the water removed. Hence an extended and careful study of the crops available for culture in such tracts becomes a pressing necessity. Such a study will of necessity involve years of investigation, both of the practises in countries where some such systems exist and of possibilities under our own conditions of available crops, markets, machinery, etc.

A short résumé, however, of some of the crops which already have some claim to notice and those which give promise of availability will help to show the possibility and practicability of such a system.

Among the plant crops which may be mentioned are water cress, which is already an article of considerable commercial value, but probably much less used in this country than elsewhere and doubtless much less than if the supply were increased. Methods of its culture are, of course, well known and would be simply a matter of adaptation to particular areas. The cranberry is also a well-known crop, adapted to bog or swamp conditions and for which there is unlimited demand.

Some of the marsh grasses, cat tails, rushes and other plants make a most abundant growth, and in association with other crops could no doubt be cultivated to good advantage. The basket willows are of great value and are used extensively in the manufacture of baskets, an industry which is capable of much expansion. The pond lily surely offers an opportunity for a most valuable aquatic crop, if systematically cultivated and harvested, especially in the vicinity of large cities and popular excursion resorts.

We may mention, also, the development of the industry, based on the slough-grasses of the northwest, including the manufacture of binding twine, mattings or carpetings and furniture. This utilizes an extensive area of wet land, not available for other crops, and which, if retained for this crop, doubtless could be utilized also in the culture of some other more distinctly aquatic crop. Other fiber plants are a possibility.

Of animal crops which are already known, fish culture is the most extended, but in general this is not reduced to a systematic farming basis. I can recall the furore created some twenty-five or thirty years ago, in connection with the introduction and proposed production of carp, but so far the carp industry in this country is mainly confined to that grown without attention, and gathered indiscriminately by fishermen without reference to any private rights. The market for this fish has, however, greatly increased and in centers where there is a large European population, as in New York City or Chicago, immense quantities are sold, and it is claimed that these people prefer carp to other fish which are greater favorites with American tastes. Under other names carp are sold to a considerable extent in our markets and, under such disguises as "smoked sturgeon," may pass as a distinct delicacy. This fish, on account of capacity for rapid multiplication and growth in restricted quarters and in ponds with abundant vegetation, is, perhaps, one of the most available for systematic cultivation. Other fishes, such as catfish and some of the species of bass, could be utilized in certain situations to good advantage.

While frogs have not been, as yet, a very common article on our markets, I do not know that the market has ever been over-stocked, and in the vicinity of large cities it would seem that a much larger quantity could be disposed of. As it is, immense numbers are utilized in the laboratories of schools and colleges, this demand being met for the most part by the capture of frogs in natural ponds. Crayfishes have not attained any special market value in the majority of markets, but I am told that they are sold to a great extent in New York City, and I see no reason why they should not be used as much as shrimp. Terrapin and no doubt other species of turtles could be marketed in much greater numbers than they are at present if their cultivation were systematized and markets properly handled. Both ducks and geese, while reared, so far as domestic species are concerned, very largely on land, would no doubt thrive better and get the best part of their growth on aquatic plants which form the greater part of their native food. They could be readily cultivated in connection with other crops.

The shells of fresh-water clams have been the basis for the establishment of some extensive button factories and the pearls that they produce have furnished a livelihood to a considerable number of individuals. But it is said that many of the factories have had to close on account of the exhaustion of the clams in adjacent streams. Doubtless, some reasonable system of gathering the shells or providing for the propagation and growth of successive generations would easily make this a permanent crop in suitable waters.

Alligator hides have a high commercial value and are all too scarce, with good prospect of disappearance from the extermination of the ungainly animal that produces them. I do not know that an alligator farm, fenced out in a suitable swamp or bayou, would be a commercial success, but it would seem well worth while to experiment in some of the swampy wastes in the domain of this prince of reptiles.

It may be somewhat remote, but it seems conceivable that it would be possible to utilize some fur-bearing animals in this direction, as, for instance: the beaver, muskrat, and possibly the otter, as these animals could certainly be colonized in suitable localities where an abundant water supply at a fairly constant level is available. As to possibilities of securing any regular crop from such animals, we have little data to guide us, but we know that under natural conditions they multiply at a fairly rapid rate. Muskrats in some localities are caught and marketed for food as well as for the skins.

With regard to salt or brackish water crops, we have already a good deal of knowledge, and with some animals and for certain localities quite thoroughly organized systems of cropping have been established; for instance, the sponge farms in Florida and oyster farming in some of the Atlantic states. The latter, however, are by no means so fully regulated as to secure the best results, as is shown by the exhaustive discussion of the subject by Professor Brooks. His estimate that the product from Chesapeake Bay of $2,000,000 annually, could and should be increased to $60,000,000, has, I believe, never been challenged, and indicates the possibilities. There are other marine forms like lobster, crab, shrimp and turtles which would lend themselves to similar definite systems of cultivation, and in fact a study of the basis for such systems has been in progress in the Bureau of Fisheries for many years past. It is necessary, however, that the results be carried into definite regulations or embodied in appropriate legislation in order to secure perpetuity in the crops and the most profitable returns.

In many instances, in both salt and fresh water areas, there will need to be entirely new legislative enactments providing for the regulations of water areas in which certain more or less sedentary animals may be cultivated. For such as migrate freely in the open waters there is perhaps no better policy than to permit capture by any individual under such restrictions as to season and quantity as may serve to protect the future supply. If animals have a fixed habitat and are capable of artificial propagation or culture, there is no logical reason why a person who plants and cares for such a crop should not be protected in the right to harvest it. Under existing laws, however, there is great difficulty in securing such rights, as all waters which have any connection with navigable streams or lakes are assumed to be public property. It would be entirely practicable, however, to guard the rights of property in the bottoms or shores without interfering in their public use for navigation, pleasure or even for fishing for such forms as are migratory. These are questions, however, which can be worked out when once the advantages of systematic cropping of water areas is fully recognized.

Aside from measures which utilize existing areas of swamp it appears to me that great advancement may be made in the combination of certain land and water crops, for instance, in a tract of marshy land having practically a constant level it would seem possible to alternate strips of land and water by the use of suitable dredging appliances, the land portion being utilized for the cultivation of such intensive crops as celery, asparagus, onions, strawberries, blackberries, etc., the fertility being maintained by adding dredged materials from the bottom of adjacent water strips. The water strips could then be utilized in the culture of such aquatic forms as fish, frogs, clams, turtles, ducks, etc., as may have the greatest value in the particular localities. By these methods we should avoid the loss incident upon constant drainage of water, secure an unfailing irrigation for crops cultivated in the land portion, secure a valuable source of fertility, and at the same time a valuable aquatic crop. Systems of this character, however, would be gradually developed and modified to suit conditions of particular localities.

A recent number of the *National Geographic Magazine* gives the areas of swamp lands in the United States (not including Alaska) at sixty millions of acres, almost entirely in the humid regions of the Atlantic slope and the Mississippi Valley.

A bulletin issued later by the U. S. Department of Agriculture gives an estimate of 77,000,000 of acres for swamp and overflowed lands and claims a possible reclamation of practically this entire area.

Both of these authors put great stress upon the wealth to be gained by the drainage of this area, and discuss some of the great national and state projects already in view, but no hint is given by either that any part of this vast area could be put to useful service except by disposing of the water.

Sir Edwin Ray Lankester
Who has recently retired from the directorship of the British Museum of Natural History

THE PROGRESS OF SCIENCE

ADMINISTRATIVE METHODS IN AMERICAN UNIVERSITIES

Recent events at Syracuse, Cincinnati and Oklahoma direct attention to the anomalous conditions of university control that obtain in this country. Elsewhere throughout the world the university is a republic of scholars, administered by them. Here it is a business corporation. The ultimate control is lodged in a board of absentee trustees, whose chief duty is the election of a president. The qualifications most regarded in the president are the ability to get money for the institution and a good presence at public functions; but he is expected to "run" the university. The professors and instructors are employed "at the pleasure of the trustees," and so long as the president maintains his position this means at his pleasure. Advances in salary or position, appropriations for apparatus, etc., are subject to the same pleasure. In larger institutions the department-store system naturally grows up. Deans and heads of departments are responsible to the president, and their subordinates are responsible to them.

As a matter of fact, men are not dominated by governments and laws, but conversely. In a great university, such as Harvard, courtesy and consideration do not fail. In the smaller colleges, there is the spirit of the family. So long as the best men are found at our colleges and universities, it may not matter greatly under what system of academic government they live. But there is real danger that the existing system may prove repulsive to men of the highest intelligence and character, and that mediocrity and time-serving may be developed, where we need the most vigorous ability and independence. Then we have occasional academic scandals which exhibit the seamy side of the system.

At Syracuse University the chancellor did not like the dean of the School of Applied Science, and has dismissed him, giving no grounds except that he had been a disappointment to the administration. However this may be, it appears that the dean has conducted the affairs of his school with skill, and has the sympathies of his colleagues at Syracuse and in the engineering profession, of the students and the alumni. A competent engineer can earn far more by practising his profession than as a professor, and the Syracuse dean has not been forced to sacrifice his independence to feed his children. He has consequently conducted a good public fight, which will doubtless lead to an improvement of affairs at Syracuse and elsewhere. The Syracuse chancellor has written: "Our professors have nothing to do with the hiring, continuing or dismissing of professors and students." But when Syracuse recently needed a professor of botany, men looked askance at the position, and the same thing will happen now when the deanship of the school of engineering must be filled. Neither the largest stadium in the world, nor a chancellor who is a methodist orator, nor a president of a board of trustees, whose corporation controls the kerosine of the country, suffices to make a university.

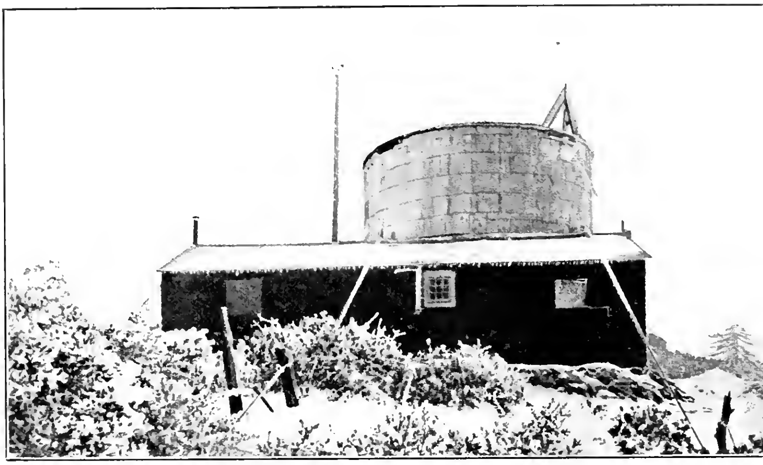
At the University of Cincinnati there was a few years ago a deplorable state of affairs. A president was brought there to dismiss a large part of the faculty and then he was in turn dismissed. Now the head of the department of philosophy has been dismissed because his family relations are not approved. It is not alleged that he is immoral, and it is admitted that he is a good teacher and an able investigator, but his conduct and opinions are said to be subversive of the family. Whatever may be the merits of the case, the administrative methods do not show to advantage.

In the new state of Oklahoma "the best constitution in the world" has not provided an ideal educational system. Indeed the conditions approach *opera bouffe* too nearly to be taken quite seriously. The head of the state university, the heads of the normal schools and of other institutions have been dismissed and supplanted by southern democrats. At the university the question appears to be not whether a professor is an able teacher and investigator, but whether he is a good southern methodist and democrat, who does not dance. Such conditions are transient. The danger is that methods which can not be approved in politics and business may obtain such footing in our universities that they will no longer be centers of democratic individualism and of intellectual and moral leadership.

THE BOYDEN DEPARTMENT OF THE HARVARD COLLEGE OBSERVATORY

Uriah A. Boyden, a Boston inventor and engineer who died in 1879, bequeathed property valued at over $230,000 for "the establishment and maintenance of an astronomical observatory on some mountain peak at such an elevation as to be free, so far as practicable, from the impediments to accurate observations which occur in the observatories now existing, owing to atmospheric influences." The fund was transferred by the trustees named in the will to the Harvard College Observatory, which carried out the provisions by the establishment of the Arequippa Observatory in Peru. An illustrated account of this mountain observatory and of the researches that have been undertaken there was contributed to a recent volume of the Monthly by the director, Professor Solon I. Bailey. Prior to the foundation of the Arequippa Observatory in 1891, several expeditions were sent out to determine the conditions that would best fulfil the terms of Mr. Boyden's will, and an account of this preliminary work has just been published in "The Annals of the Harvard College

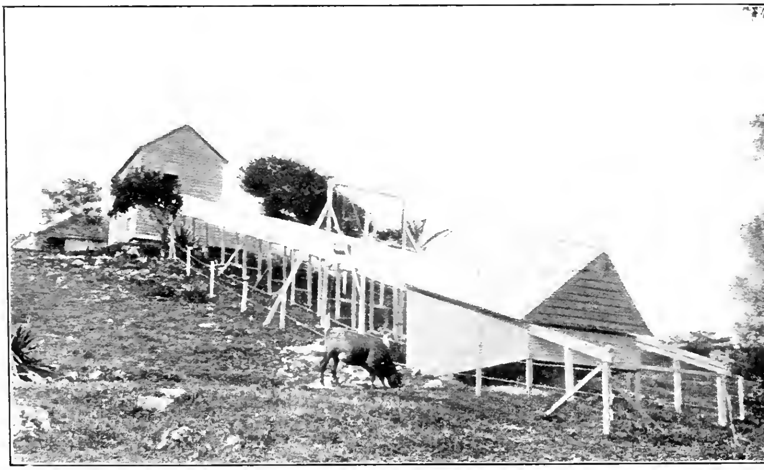
Station at Pike's Peak.



STATION AT MT. WILSON.

Observatory,' by Professor William H. Pickering.

The first expedition was to the summit of Pikes Peak, in 1887, where at an altitude of 14,200 feet, there was a stone hut erected by the U. S. Signal Service. Observations were made for a month, and it was concluded that altitude was not as important a factor in "the seeing" as dryness. In the following year an expedition went to California and erected a pier and a building with a revolving drum on Mt. Wilson at an altitude of 5,700 feet. This observatory was occupied for more than a year, and the definition was found to be good. There was, however, some question as to the title of the land and there were advantages in selecting a location for the observation of southern stars. As Mr. Bailey had reported favorably on the Peruvian climate, the next expedition was sent there, and the Mt. Wilson site was abandoned. It has since been occupied by the buildings and fine instruments of the Solar Observatory of the Carnegie Institution.



STATION AT JAMAICA.

The expedition to Peru arrived in Arequippa at the beginning of 1891, and a site for the observatory was selected on the crest of a ridge about 300 feet above the city. Here was erected an observatory in which there have been carried forward under the direction of Professor Bailey important observations on the southern stars.

After working in the observatory established by Professor Lowell in Arizona, Professor W. H. Pickering concluded that neither dryness nor altitude is the important factor affecting the quality of the seeing, and, in order to study the problem further, an expedition to Jamaica was undertaken in 1899, where observations were made at several stations from the sea-level to an altitude of 2,300 feet. In a second Jamaica expedition the following year a horizontal telescope, with an 18-inch mirror and 15-inch lens, was erected at Mandeville.

Professor Pickering concludes that elevation above the sea-level gives somewhat better definition, especially towards the horizon, and avoids dust and haze. A dry climate has advantages in its freedom from dew, cloud and fog, but does not give better definition than one that is moist. A low latitude has three advantages: The definition is better, the bodies to be observed pass near the zenith and a larger portion of the heavens is brought into view.

THE HANOVER MEETING OF THE AMERICAN ASSOCIATION

On the invitation of Dartmouth College the American Association for the Advancement of Science will hold a special meeting at Hanover, N. H., from June 29 to July 3. The American Physical Society and the Geological Society of America will meet with the association, and regular programs will be arranged only in physics and in geology. There will, however, be public lectures and numerous interesting excursions, and those able to attend may look forward to a pleasant visit to a typical New England college under the most favorable conditions. The railways offer rates of a fare and a third on the certificate plan, and excellent local arrangements are assured for the entertainment of visitors.

Many members regret the transfer of the annual meeting of the association from the summer to the winter. It is certainly true that the large meetings in a city are likely to sacrifice the social pleasures to business efficiency and to neglect one of the main objects of the association—the diffusion of science. A meeting such as this at Hanover should be attractive to those who wish to meet their colleagues amid pleasant surroundings, and to those not professionally engaged in scientific work but interested in it. Men and women of this class are especially welcomed to the present summer meeting and may feel free to attend without being elected in advance to membership. Those who go are certain to find the meeting both pleasant and useful.

SCIENTIFIC ITEMS

We record with regret the deaths of Dr. Heinrich Maschke, professor of mathematics in the University of Chicago; of M. Albert de Lapparent, the eminent French geologist; of Dr. K. Möbius, professor of zoology at Berlin, and of Dr. Pierre Jacques Antoine Béchamp, eminent for his researches in organic chemistry.

The house of representatives concurring with the senate and by a unanimous vote, has granted an annuity for life of $125 a month to the widows of the late Major James Carroll, surgeon, U. S. army, and the late acting assistant surgeon, Jesse W. Lazear, whose lives were sacrificed in the study of yellow fever in Cuba.

THE POPULAR SCIENCE MONTHLY.

AUGUST, 1908

THE HISTORY OF THE CONSERVATION OF ENERGY; THE AGE OF THE EARTH AND SUN

By Professor FLORIAN CAJORI

COLORADO COLLEGE

IN the small town of Heilbronn, in Würtemberg, stands a monument erected to the memory of the physician, Robert Mayer. It was unveiled in 1892, just fifty years after the publication of Robert Mayer's first essay on the conservation of energy. His career as a scientific discoverer is marked by many pathetic incidents. After the study of medicine he was made sanitary officer on a Dutch vessel, bent for the East Indies. During the long ocean voyage on the slow sailing vessel he was left much to himself. He gave his leisure hours to the contemplation of scientific subjects. He had occasion to observe that, in tropical countries, blood taken from the veins of patients looks almost like arterial blood. He concluded that in the tropics less oxidation is necessary than in a cold climate, in order to maintain a uniform bodily temperature. There must be a quantitative relation between the amount of heat generated and the temperature in which we live. In cold, northern climates more heat must be developed for the maintenance of uniform bodily temperature. During the 219 days between February and September, 1840, spent on the water, Mayer dwelt in close intellectual communion with nature, and she gradually revealed to him one of her most precious secrets. Upon his return to Heilbronn he kept on thinking. A moving body is brought to rest by friction; heat appears. Has the motion disappeared into nothing? Has heat sprung out of nothing? If not, then there must be an equivalence between the heat generated and the motion destroyed. *Causa æquat effectum,* "Cause is equal to effect," became his favorite axiom. At first he thought that kinetic energy varied as the velocity. Later he recognized his error and perceived its variance with the square of the velocity.

On June 16, 1841, he sent an essay embodying his new ideas for publication in *Poggendorff's Annalen,* but the manuscript was not published nor was it returned to the author.[2] Thirty-six years later it was found among the papers of Poggendorff. In 1842 Mayer prepared a second short paper of seven pages and had the satisfaction of seeing it printed in *Liebig's Annalen der Chemie.* This was a happy time in his life, for at the very hour when he learned of the acceptance of his manuscript, he was bringing home his bride and presenting her to his aged parents.[3] But it is one thing to secure the publication of a manuscript and quite another thing to get scientific men to read and study it. A new discovery necessitates a new language. A new language is not generally understood. The curse of Babel fell upon Mayer's paper: "Confound their language, that they may not understand one another's speech." Other papers were printed by Mayer as pamphlets in 1845 and 1848.

Something of the personality of Mayer may be gained from the following stories.[4] During a hurried meeting with Mayer in Heidelberg once, Jolly remarked, with a rather dubious implication, that if Mayer's theory were correct water could be warmed by shaking. Mayer went away without a word of reply. Several weeks later . . . he rushed into the latter's presence, exclaiming, "Es ischt so!" (It is so, it is so). It was only after considerable explanation that Jolly found out what Mayer wanted to say. Of metaphysics Mayer had no appreciation. Rümelin narrates that in 1841 Mayer borrowed from him a copy of Hegel's "Logik" and Hegel's "Naturphilosophie," but returned the books a few days later with the remark that he did not understand a word, and that he could not understand any part of it, were he to study it a hundred years.[5]

For years Mayer was unable to bring his great discovery to the serious attention of scientific men. Later there followed controversies on his rights of priority. A gloom fell upon him through the death of two of his children. His mind became seriously affected, and on May 26, 1850, he unsuccessfully attempted suicide by jumping from a second-story window. In 1851 he was placed in an insane asylum, where he was cruelly treated. Two years later he was set free, but he never again regained complete mental equilibrium. Such is the pathetic story of the first discoverer of the conservation of energy.[6]

[2] "Mechanik der Wärme," von R. Mayer (ed. J. J. Weyrauch), Stuttgart, 1893, p. 16; "Kleinere Schriften u. Briefe," von Robert Mayer (ed. J. J. Weyrauch), Stuttgart, 1893, V., p. 99.

[3] "Kleinere Schriften," p. 379.

[4] Mach in the *Monist*, Vol. 6, 1896, p. 171, copied in Cajori's "History of Physics," New York, 1899, p. 210. Several passages in this address are taken from this "History of Physics."

[5] G. Rümelin, "Reden und Aufsätze," Freiburg i. B., 1881, p. 380.

[6] For a statement, by Clausius, explaining the manner in which Mayer's

In 1858 a few voices were heard in Germany in praise of Mayer, but the one who did most to bring him historical justice was John Tyndall, who in 1862 lectured before the Royal Institution on Robert Mayer.[7] I shall remain silent on the extremely bitter controversy, between Tyndall and Tait, regarding Mayer's researches.[8] Tait and William Thomson placed a low estimate on Mayer's work and brought the charge that Tyndall, by praising Mayer, was belittling the work of Joule. One would suppose that gross historical errors would have been eliminated by this time from a subject like the conservation of energy, about which so much has been written. Such is not the case. Professor R. T. Glazebrook, writing in the great "Dictionary of National Biography" (article, "Joule"), said in 1892, just before the publication of Mayer's correspondence, that Mayer in 1842 endeavored to measure the heat produced in the compression of air, but committed the very serious mistake of assuming without experimental evidence that "all the mechanical energy spent in compressing the air was used in producing change of temperature." This same criticism was passed upon Mayer by Joule, Tait and Helmholtz. A fundamental question is here involved, but the charge is not true. As early as September 12, 1841, in a letter to his friend Professor Baur, Mayer explained Gay-Lussac's experiment of 1807 on the flow of gas into a vacuum, and drew upon it to complete his argument on the equivalence of the work of compression and the heat generated by the compression. Gay-Lussac had found that when a gas expands into a vacuum it undergoes no change in temperature large enough to be detected by his thermometers. Hence, during compression practically all the work done upon the gas goes to produce change of temperature, and Mayer's argument is sound. That the criticism of Mayer's reasoning is invalid is not generally known to recent writers on the subject, but can now be verified by any one who will examine Mayer's collected works and letters, edited by Weyrauch in 1893.[9] It should be added, however, that Mayer himself is partly to blame for the strictures passed upon his paper of 1842. Gay-Lussac is not mentioned and the whole matter is disposed of in a single sentence, though that sentence, we admit, is somewhat Germanic in its structure and linear dimensions.

publications became known, consult "Die Mechanische Wärmetheorie," von R. Clausius, dritte umgearbeitete und vervollständigte Auflage, Erster Band, Braunschweig, 1887, pp. 394–403.

[7] *Proceedings of the Royal Institution*, June, 1862; *Philosophical Magazine*, Vol. 24, p. 57.

[8] See Thomson and Tait's article in the *Philosophical Magazine*, April, 1863, and various articles by them and Tyndall in Vols. 25 and 26 of the *Philosophical Magazine*, as well as translations into English of Mayer's papers.

[9] "Kleinere Schriften u. Briefe," p. 131; "Mechanik der Wärme," pp. 53, 130, 269.

Mayer's failure to secure recognition from the scientific public found its counterpart on a smaller scale with Joule and Helmholtz.

Joule was the son of a wealthy brewer. In 1830 he saw the first trains which traveled between Liverpool and Manchester. One of the happy circumstances of his boyhood life was his connection with John Dalton and Dalton's laboratory containing effective home apparatus. His association with Dalton gave direction to his constructive genius. Joule's father fixed up a room for a chemical laboratory. Before the boy was of age he began experimentation in chemistry and electricity.

After laborious tests he succeeded in showing that the heat developed by the union of two chemical elements effected in a battery is the same as that developed by combustion, and that the heat has a definite equivalent in the electromotive force between these elements.[10] He studied the relations between electrical, chemical and mechanical effects and was led to the great discovery of the mechanical equivalent of heat. In a paper read before the British Association in 1843 he gave the number as 460 kilogrammeters. This was only one year after Mayer had published his first paper. Friends who recognized the physicist in the young brewer persuaded him to become a candidate for the professorship of natural philosophy at St. Andrews, Scotland, but his slight personal deformity was an objection in the eyes of one of the electors and he did not receive the appointment.

The early papers of Joule attracted little attention. His facts were so novel, so apparently heterodox, and the language in which they were conveyed so unfamiliar, that the older physicists permitted them to remain without due consideration. Faraday was then busy with his experimental researches. Graham was studying the diffusion of gases. Wheatstone, Whewell, Herschel, Forbes, Airy were engrossed with problems of their own. Those who were first to applaud Joule a few years later were still pupils. William Thomson and Gabriel Stokes were at Cambridge; Rankine, a youth of 22, was studying engineering; Tait was a boy at school; Clerk Maxwell had just acquired the nickname of "Dafty" at Edinburgh Academy. In 1844 a paper of Joule, "On the Changes of Temperature produced by the Rarefaction and Condensation of Air," was rejected for publication by the Royal Society, but was printed in the *Philosophical Magazine* the year following.[11]

In April, 1847, Joule gave a popular lecture in Manchester, delivering the first full and clear exposition in England of the universal conservation of that principle now called energy.[12]

[10] "Memoir of James Prescott Joule," by Osborne Reynolds, 1892, p. 50.

[11] Reynolds, op. cit., p. 78.

[12] Reynolds, op. cit., pp. 104, 105.

The local press would at first have nothing to do with it. One paper refused to give even a notice of it. The *Manchester Courier*, after long debate, published the address in full. In June, 1847, the subject was presented before the British Association meeting at Oxford. The chairman suggested that the author be brief. No discussion was invited. In a moment the section would have passed on to other matters without giving the new ideas any consideration, if a young man had not risen from his seat and by his intelligent observations created a lively interest in the new theory. The young man was William Thomson, now better known as Lord Kelvin. The result was that the paper caused a great sensation. Joule had attracted the attention of scientific men. After the meeting Joule and Thomson discussed the subject further and the latter obtained ideas he had never had before.

Joule experimented on the mechanical equivalent of heat for about forty years. By magneto-electric currents he got in 1843 the value of 460 kilogrammeters as the equivalent of the large French calorie. By the friction of water in tubes he obtained 424.9; by the compression of air, in 1845, 443.8; by the friction of water he obtained, in 1845, 488.3; in 1847, 428.9; in 1850, 423; in 1878, 423.

Comparing Joule with Mayer, it will probably be admitted nowadays that Joule stands first as an experimentalist, while Mayer towers above Joule as a generalizer, as a physical philosopher.

The same year, 1847, in which Joule announced his views on energy before the British Association, Helmholtz, a youth of 26, read before the Physical Society in Berlin a paper on the same subject, entitled, "Die Erhaltung der Kraft." It was at first pronounced a fantastic speculation. The editor of *Poggendorff's Annalen*, who in 1841 declined Mayer's paper, rejected Helmholtz's also. As Joule was supported by William Thomson, so Helmholtz was defended by his fellow-student Du Bois-Reymond, and by the mathematician C. G. J. Jacobi. Helmholtz's paper was published in pamphlet form in 1847. For a time it attracted little notice, but in 1853 some parts in it were vigorously attacked by Clausius in *Poggendorff's Annalen*. Later it subjected its author to bitter attacks from Eugen Karl Dühring[13] and others, who accused him of being a dishonest borrower from his forerunner, Robert Mayer. In a publication of 1898, issued in Berlin, Dr. Thomas Gross does not quite accuse Helmholtz of plagiarism, but claims that Helmholtz did all he could to discredit Mayer. In my judgment both Dühring and Gross failed to establish their contentions. In the absence of clear evidence to the contrary we prefer to accept Helmholtz's own statement, as given in one of his lectures. Helmholtz says in one place, "The first who saw truly the general law here

[13] Dr. E. K. Dühring, "Robert Mayer, der Galilei des Neunzehnten Jahrhunderts," Chemnitz, 1880; Zweiter Theil, Leipzig, 1895.

referred to and expressed it correctly was a German physician, J. R. Mayer, of Heilbronn, in the year 1842." Then he says, "I myself, without being acquainted with Mayer or Colding, and having first made the acquaintance of Joule's experiments at the end of my investigations, followed the same path."[14]

We have now briefly sketched the birth of the principle of the conservation of energy in the minds of Mayer, Joule and Helmholtz. After examining the facts we are convinced that these great physicists were independent discoverers. Lack of time prevents us from making reference to forerunners like Count Rumford,[15] Sadi Carnot,[16] Séguin,[17] Mohr[18] and to the Dane, named Colding,[19] who in 1843 gave utterance to the law before the Academy in Copenhagen. We pass by the researches of Rankine, to whom we owe the expression, "conservation of energy," as well as William Thomson's doctrine of the "dissipation of energy."

We come now to the second part of this paper—the application of the conservation of energy and other principles of physics to the examination of the age of the sun and of the earth. The two problems are closely interrelated; the earth-age is measurable by the sun-age.

Before the time of the Scotch geologist, James Hutton, some 6,000 years was believed to indicate the age of the earth, and, indeed, of the entire universe. The advent of the uniformitarian school of geologists marks a radical departure from the old estimates. The pendulum swings from one extreme to the other. Boundless distances of time were now drawn upon. So great an antiquity of the earth seemed to reveal itself to geologists, as to defy all attempts at measurement. In the further pursuit of Hutton's line of investigation, Playfair and Lyell were unable to discover among the records of the earth and in planetary motion either a beginning or an end of the present order of things. They found no indication of infancy or decaying old age.[20]

This convenient doctrine of infinite durability came to be rudely attacked by the physicists. Here, as in the history of the conservation of energy, the earliest investigator is Robert Mayer. To be sure, he

[14] "Popular Lectures," by H. Helmholtz (transl. by E. Atkinson), New York, 1897, p. 167.

[15] "The Complete Works of Count Rumford," published by the American Academy of Arts and Sciences, Boston, Vol. I., pp. 481–488.

[16] "Réflexions sur la puissance motrice du feu," 1824, reprinted in *Ostwalds Klassiker*, No. 37; English translation by R. H. Thurston appeared in 1890.

[17] "De L'influence des Chemins de Fer," Paris, 1839, pp. 378–397.

[18] "Allgem. Theorie der Bewegung," Braunschweig, 1869, pp. 80–84.

[19] A. Colding, Det. Kongel. dansk vidensk. selsk. naturv. ogmath. afh. (5), II., 1843, p. 121, 167.

[20] Sir Archibald Geikie, presidential address before British Association, in *Report, British Association for the Advancement of Science*, 1892, Vol. 62, pp. 3–26; *Smithsonian Report*, 1892, p. 124.

did not attempt an estimate of the age of the solar system, but he discussed the preliminary question as to the source of solar heat. As soon as Mayer had convinced himself that energy can not be destroyed, and that the energy of the earth comes mainly from the sun, he began to study what Sir William Herschel had called "the great secret" of the maintenance of solar heat. In 1841, before the publication of his first paper, he asked questions relating to solar heat, in a letter to Baur, "Is it the glowing of the sun? Why does he not cool off? Is it a burning depending upon willing meteoric stones?"[21]

In 1846 he had a paper ready on this subject. Being reminded by a friend that no one can be a prophet in his own country, he sent the paper to the Academy of Sciences in Paris. A committee of the academy was directed to report on this paper, but it failed to do so and the paper was ignored. It could be published only at his own expense. It appeared in 1848 under the title, "Celestial Dynamics." Mayer concludes that the sun can not be a glowing mass, sending out radiation without compensation; solar heat can not be due entirely to chemical changes; solar heat can not be due to solar rotation. He finally embraces the theory that solar heat is due to the energy of meteors falling into the sun. He did not overlook the fact that the resulting increase of mass of the sun would increase its attraction for the planets, and would shorten the sidereal year. He knew that observation does not disclose any variation in the length of the year. An easy explanation would be offered by Newton's corpuscular theory of light, according to which the sun sends out matter into space. But this theory was then known to be untenable. In this dilemma Mayer takes refuge in an idea which rests on a misconception of the undulatory theory of light, and he offers an explanation which is now easily recognized as invalid.

From Mayer we pass to William Thomson, the late Lord Kelvin, who, six years later, took up the very same problem and arrived independently at almost identically the same conclusions. That solar heat may be due to falling meteors was first suggested in England by Waterston. Unlike Mayer, Thomson sees no objection to the increase in the sun's mass resulting from meteoric showers, for, "according to the form of the gravitation theory" which he proposed, "the added matter is drawn from a space where it acts on the planets with very nearly the same forces as when incorporated in the sun." In an appendix to the paper, Thomson ventures an estimate of the age of the sun. This is the first attempt, made by a physicist, to compute the age of our great luminary and to prepare a mortuary estimate of it. He goes on the supposition that the solar energy of rotation is derived from the energy of falling meteors. He calculates that, allowing for the constant loss

[21] "Mechanik der Wärme," p. 146.

of solar energy by radiation, the sun could acquire its present energy of rotation in thirty-two thousand years. From an estimate of the limited amount of meteoric matter available near the sun, he concludes that "sunlight can not last as at present for three hundred thousand years." This calculation of the year 1854 attracted no attention at the time. Later, the theory was abandoned by its author, as at variance with known facts.

Evidently the theory of solar heat was still in a very crude form. But important new ideas were brought into view in the same year, 1854, by Helmholtz, in a popular lecture at Königsberg, delivered on the occasion of the Kant commemoration.[22] Unlike Mayer and Thomson, he starts out with the nebular hypothesis of Kant and Laplace, and derives solar heat from nebular contraction. During the contraction of the nebula from which sun and planets were formed, and also during the contraction of the sun, now assumed to be in progress, the kinetic energy obtained thereby is converted into heat and compensates for the loss of solar heat by radiation. He concludes that if the sun contracts the ten-thousandth part of its radius enough heat is generated to supply radiation for 2,100 years.[23] His figures yield twenty-two million years as the probable age of the sun, on the assumption of uniform radiation and homogeneous density. Experimental data on the intensity of solar radiation, found later by Langley, reduced this age to eighteen million or less.

Helmholtz's theory was a tremendous advance on that of falling meteors, assumed by Mayer and Thomson. No doubt meteors fall into the sun, as assumed by Mayer and Thomson, but the Mayer-Thomson theory made demands upon these meteors that bordered on extravagance. We are certain that a part of the solar heat is due to falling meteors, but its amount is as nothing, compared with the heat resulting from the gravitational energy of shrinkage. Until recently these were the only important sources considered.

In the sixties fresh attacks were made on the problem of the age of the sun by William Thomson. In 1862 appeared in the *Macmillan's Magazine* an article, "On the Age of the Sun's Heat,"[24] in which he favors a meteoric theory like that of Helmholtz, by which there is no difficulty in accounting for 20,000,000 years' heat radiated by the sun. He concludes that we may accept "as a lowest estimate for the sun's initial heat, 10,000,000 times a year's supply at present rate, but 50,000,000 or 100,000,000 as possible, in consequence of the sun's greater

[22] H. Helmholtz, "Popular Lectures" (transl. by E. Atkinson), New York, 1897, pp. 153–193, "On the Interaction of Natural Forces."

[23] Op. cit., p. 190.

[24] Sir William Thomson's "Popular Lectures and Addresses," Vol. I., 1891, pp. 356–375.

density in his central parts."[25] "As for the future, . . . inhabitants of the earth can not continue to enjoy the light and heat essential to their life, for many million years longer, *unless sources now unknown to us are prepared in the great store-house of creation.*" More detailed studies of the same subject were made in 1887, in a lecture "On the Sun's Heat," delivered before the Royal Institution of Great Britain.[26]

In this lecture Sir William Thomson refers to a very able paper, "On the Theoretical Temperature of the Sun," by J. Homer Lane,[27] of Washington, which establishes the apparently paradoxical statement that, within certain limitations, the more heat a gaseous body loses by radiation, the hotter it will become. This theorem was discussed in connection with the solar heat by Benjamin Peirce,[28] Simon Newcomb[29] and Sir Robert Ball.[30] Results similar to Lane's were reached in the years 1878–83 in a series of very exhaustive papers by A. Ritter.[31] A rival to the Helmholtz-Thomson theory of solar heat was advanced about 1882 by William Siemens,[32] who imagined the rotating sun to hurl, by centrifugal action at his equator, enormous quantities of gas into space, which returned to him again at the poles.

A refinement of the theory as presented by Helmholtz was introduced in 1899 by T. J. J. See,[33] wherein he abandoned the Helmholtzian hypothesis of a sun of homogeneous density and, using Lane's law, investigated minutely the more complex case of central condensation. Thereby the probable solar age was extended from about 18 to about 32 million years.

Returning to the problem of the age of the earth, considered independently of the sun, we find William Thomson the great moving spirit. He approached the subject from more than one point of view. One argument for limitation of the earth's age was based on the consideration of underground heat.[34] "The heat which we know by

[25] Op. cit., p. 375.

[26] Op. cit., pp. 376–429.

[27] *American Journal of Science*, 2d S., Vol. 50, 1870, pp. 57–74.

[28] *Proceed. Am. Acad.*, XV., p. 201.

[29] "Popular Astronomy," 1st ed., p. 508; "The Stars," New York, 1901, p. 210.

[30] "Story of the Heavens," London, 1893, p. 497.

[31] *Wiedemann's Annalen*, V., p. 405; X., p. 13; XI., p. 978; XII., p. 445; XIII., p. 360; XIV., p. 16; XVI., p. 166; XVII., p. 322; XVIII., p. 488; XX., pp. 137, 897. See Rosenberger, "Geschichte der Physik," Vol. III., 1887, pp. 689, 690.

[32] "Ueber die Erhaltung der Sonnenenergie," Uebersetzt von C. E. Worms, Berlin, 1885; see Rosenberger, "Geschichte der Physik," Vol. III., p. 687.

[33] *Science*, N. S., Vol. IX., 1899, pp. 737–740.

[34] W. Thomson, "The Doctrine of Uniformity in Geology Briefly Refuted," read in 1865 before the Royal Society of Edinburgh. See *Smithsonian Report*, 1897, p. 343.

observation to be now conducted out of the earth yearly is so great that if this action had been going on with any apparent uniformity, the history of life on the earth could not exceed a few thousand million years." Another consideration leading to similar conclusions was based on the shape and rigidity of the earth. With Sir William Thomson, the age of the earth continued to be a question studied with great predilection. His aim was not so much to determine the exact age as to fix an upper age limit. As the years passed by, investigation supplied much of the knowledge which was at first wanting regarding the thermal properties of rocks, and Sir William Thomson was able greatly to reduce this upper limit.

"The Physical Condition of the Earth" was the topic of Sir William Thomson's presidential address in 1876, before Section A of the British Association. He took the gradual increase of temperature downwards to be on an average 1° C. for 30 meters of descent and gave reasons for his belief that for great depths the rate of increase does not diminish. He concludes that if at great depths the temperature does not exceed 4,000° C., then the geological age of the earth does not exceed 90 million years. This argument involves some very uncertain factors. Sir William Thomson has shown quite conclusively that the earth's interior is solid, but at what temperature the substance of the earth would begin to melt under the high internal pressures was a matter of pure conjecture.

About 1885 Carl Barus, of the United States Geological Survey, made a series of very important experimental researches on the physical properties of rocks at high temperatures, for the purpose of supplying trustworthy data for geological theory.[35] Mr. Clarence King, in an article published in the *American Journal of Science*,[36] used the data on specific heats, thermal conductivities and temperatures of fusion of rocks, which had been supplied by Barus, for a more accurate determination of the age of the earth. King concludes from these experimental data on diabase, "that we have no warrant for extending the earth's age beyond 24,000,000 years." A computation made by Lord Kelvin led to about the same figure.[37] These results were embodied by him in his address of 1897 before the Victoria Institute.

What was the attitude of geologists toward these researches? In England, geologists did not pretend to be able to find any flaw in the argument of Lord Kelvin, but they were in a position described in the well-known couplet,

"A man convinced against his will
Is of the same opinion still."

[35] *Am. Jour. of Science*, 3d S., Vol. 42, p. 498; Vol. 43, p. 56.

[36] "On the Age of the Earth," 3d S., Vol. 45, 1893, pp. 1–20. See also *Smithsonian Report*, 1897, p. 345.

[37] *Smithsonian Report*, 1897, p. 346.

To the geologist, yonder snow-capped peaks symbolized eternity; to the physicist, the mountains were as transient as the clouds.

A calm statement of the geologists' attitude was made before the British Association in 1892 by Sir Archibald Geikie.[38] In one place he expresses himself as follows:

> Lord Kelvin is willing, I believe, to grant us some twenty millions of years, but Professor Tait would have us content with less than ten millions. . . . I frankly confess that the demands of the early geologists for an unlimited series of ages were extravagant . . . and that the physicist did good service in reducing them. . . . That there must be some flaw in the physical argument I can, for my own part, hardly doubt, though I do not pretend to be able to say where it is to be found. Some assumption, it seems to me, has been made, or some consideration has been left out of sight, which will eventually be seen to vitiate the conclusions, and which when duly taken into account will allow time enough for any reasonable interpretation of the geological record.

Five years later an American geologist, Professor T. C. Chamberlin, invaded the domain of physics and made a vigorous attack on Lord Kelvin's argument, challenging the correctness of some of his assumptions.[39] This criticism did not secure the attention it deserved, for scientific events soon took a different turn.

Lord Kelvin's address of 1897 is permeated, as Professor Chamberlin puts it, "with an air of retrospective triumph and a tone of prophetic assurance." "It is only by sheer force of reason," says Kelvin, "that geologists have been compelled to think otherwise, and to see that there was a definite beginning and to look forward to a definite end of this world as an abode fitted for life." Nor was this feeling of retrospective triumph confined to Lord Kelvin or to the students of the problem of the age of the sun and earth. At the close of the century physicists and chemists gloried in the triumphs of their predecessors, in such achievements as are indicated by the words "conservation of energy," "conservation of mass," and "atomic theory." In physical research the nineteenth century was a golden age. It produced Faraday, Helmholtz, Mayer, Joule, Kelvin, Rayleigh, Rowland and many other great men. With the close of the century timid souls doubtless feared that the golden age had come to a close, and they perhaps experienced strange emotions like those attributed to Adam in the Garden of Eden, on seeing the sun go down, not knowing that it would ever rise again.

Others were perhaps haunted by another fear—a feeling that the great and fundamental truths of science were all revealed to the full sight of man, and it now remained only to work out the less important

[38] *Smithsonian Report*, 1892, p. 125.

[39] *Science*, N. S., Vol. IX., pp. 889–901; Vol. X., pp. 11–18, 1899. Reprinted in *Smithsonian Report*, 1899, pp. 223–246.

details. Some doubtless felt disheartened because of lack of opportunity, as did the Edinburgh anatomist, Dr. John Barclay a century ago. Dr. Barclay looked upon the great anatomists of earlier periods as "reapers who, entering upon untrodden ground, cut down great store of corn from all sides of them. . . . Then come the gleaners who gather up ears enough from the bare ridges to make a few loaves of bread. Last of all come the geese, who still continue to pick up a few grains scattered here and there among the stubble, and waddle home in the evening, poor things, cackling with joy because of their success." But the history of science shows that Dr. Barclay's reapers, gleaners and geese do not belong to separate epochs. They are contemporaneous. The reaping, gleaning and cackling go on as a rule in the same field, all at one time, in a grand comic medley of sounds. It is certain that anatomists had not so nearly exhausted their field one hundred years ago as Dr. Barclay believed that they had.

We are told that, about 1878, the president of a certain chemical society informed his hearers in an annual address that the age of discovery in chemistry was closed, and that henceforth we had better devote ourselves to a thorough classification of chemical phenomena. But at that very time Crookes was experimenting in England on high vacua, and the year following he electrified the British Association by his brilliant experiments on "radiant matter." Then came the Lenard rays and in 1895 the Roentgen rays, in 1896 the Becquerel rays and in 1899 radium, with its mysterious radiation. This was followed by the report that probably all matter is slightly radio-active. The study of these phenomena has shaken the old atomic theory, and calls for a reexamination of the principle of the conservation of energy and of matter. The earthquake in San Francisco did not shake buildings so violently as did these new facts shake the great edifice of physical science. The principle of the constancy of matter was called in question in an experiment of Kaufmann on particles shot off from radium.[40] This experiment is hard to interpret, but I am not aware that J. J. Thomson, or Rutherford, or Soddy, or Boltwood, is denying the indestructibility of matter. One French experimentalist, however, LeBon,[41] has advanced the new theory of the destructibility of matter to explain the new phenomena. He advances his new theory as a demonstrated fact, and assumes to speak *ex cathedra*, when others observe extreme caution. Were he advancing the destructibility of matter merely as a working hypothesis, few could complain; but he puts it forward as a firmly rooted fact.

[40] See J. J. Thomson, "Conduction of Electricity through Gases," 1903, p. 534.

[41] Dr. Gustave Le Bon, "The Evolution of Matter" (translated by F. Legge), 1907, Charles Scribner's Sons.

The principle of the conservation of energy has quite withstood all attacks. To be sure, Le Bon claims to have overthrown it, too,[42] but the validity of his argument is questionable. Even scientists sometimes play with logic. You have heard the story of the Assyriologist who argued: "The Assyrians understood electric telegraphy, because we have found wire in Assyria." "Oh," replied the Egyptologist, "we have not found a scrap of wire in Egypt, so we know the Egyptians understood wireless telegraphy."

In the presidential address before the British Association in 1907, Professor E. R. Lankester uttered the following weighty words: "The kind of conceptions to which these and like discoveries have led the modern physicist in regard to the character of that supposed unbreakable body—the chemical atom—the simple and unaffected friend of our youth—are truly astounding. But I would have you notice that they are not destructive of our previous conceptions, but rather elaborations and developments of the simpler views, introducing the notion of structure and mechanism, agitated and whirling with tremendous force, into what we formerly conceived of as homogeneous or simply built-up particles, the earlier conception being not so much a positive assertion of simplicity as a non-committal expectant formula awaiting the progress of knowledge and the revelations which are now in our hands." [43]

This same address touches questions of cosmical physics. It says:

> Radium has been proved to give out enough heat to melt rather more than its own weight of ice every hour; enough heat in one hour to raise its own weight of water from the freezing point to the boiling-point. . . . Even a small quantity of radium diffused through the earth will suffice to keep up its temperature against all loss by radiation! If the sun consists of a fraction of one per cent. of radium, this will account for and make good the heat that is annually lost by it.

He continues to say:

> This is a tremendous fact, upsetting the calculations of physicists as to the duration in past and future of the sun's heat and the temperature of the earth's surface. The physicists, notably Professor Tait and Lord Kelvin, . . . have assumed that its material is self-cooling. . . . It has now, within these last five years, become evident that the earth's material is *not* self-cooling, but on the contrary self-heating. And away go the restrictions imposed by physicists on geological time. They now are willing to give us not merely a thousand million years, but as many more as we may want.

Some of the views relating to radium, expressed in the summer of 1906 at the York meeting of the British Association, appeared to Lord Kelvin open to objection. It seemed to him that some of the younger

[42] Le Bon, op. cit., pp. 17, 18, 53, 54.

[43] E. Ray Lankester, inaugural address before British Association, *Nature*, Vol. 74, 1906, p. 325.

men were carried away by the strangeness of the new phenomena and were ready to adopt the most extravagant theories when there was no logical necessity for abandoning old views and, in their intoxication, were embracing new hypotheses without exercising due circumspection. After the meeting Lord Kelvin boldly opened a controversy in the London *Times*. Almost single-handed the old warrior fought with great intellectual keenness against the transmutational and evolutionary doctrines, relating to the chemical elements, framed by the younger investigators, to account for the properties of radium.[44] Among his opponents were Sir Oliver Lodge, the Hon. Mr. Strutt, Mr. A. S. Eve and Mr. F. Soddy. It can not be said that Kelvin was victorious, but the controversy helped to define the points at issue. Among other things, Lord Kelvin said that there was no experimental foundation for the assertion that the heat of the sun was probably due to radium. He was still inclined to ascribe it to gravitation. Lord Kelvin also denied that it was proved that the heat of the earth is due to radium. It was possible, he claimed, that radium does not decompose under the conditions prevailing in the interior of the earth, and in that case it emits no heat.

In considering the perturbations produced by radium in the progress of our ideas, it is well to remember that, thus far, we have been able to experiment with radium in only small amounts. Professor Lankester remarks that the Curies never had enough of radium chloride to venture on any attempt to prepare pure metallic radium.

> Altogether the Curies did not have more than some four or five grains of chloride of radium to experiment with, and the total amount prepared and now (1906) in the hands of scientific men in various parts of the world probably does not amount to more than 60 grains at most. When Professor Curie lectured on radium four years ago at the Royal Institution in London he made use of a small tube an inch long and of one-eighth inch bore, containing nearly the whole of his precious store, wrenched by such determined labour and consummate skill from tons of black shapeless pitch-blende. On his return to Paris he was one day demonstrating in his lecture room with this precious tube the properties of radium when it slipped from his hands, broke, and scattered far and wide the most precious and magical powder ever dreamed of by alchemist or artist of romance. Every scrap of dust was immediately and carefully collected, dissolved, and re-crystallised, and the disaster averted with a loss of but one minute fraction of the invaluable product.[45]

In a reinvestigation of the age of the earth it is extremely important to undertake extensive investigation of the amount of radium contained in the various rocks. Such researches have been begun by the Hon. R. J. Strutt. He has made determination of the amount of radium in rocks at the surface of the earth, and has found about

[44] See *Nature*, Vol. 74, 1906, pp. 516–518.

[45] *Nature*, Vol. 74, 1906, p. 323.

3×10^{-12} grains of radium as the average amount present in 1 c.c. of soil.

From the rate of increase of temperature below the earth's surface and the heat conductibility of rocks, Mr. Strutt concludes that radium is confined to a comparatively thin crust of the earth. While these reasons are not conclusive, they are weighty. Our incomplete knowledge of the properties and the distribution of radium and other radio-active substances, makes it necessary to suspend judgment on the age of the earth. There is no necessity that the question be settled immediately.

The same remark applies to the antiquity of the sun. Much depends upon the presence or absence of radium there. As yet this substance has not been found in the sun, but the presence of helium, combined with the fact that helium may be obtained from radium, renders the presence of radium in the sun quite probable. That radium affects the problem of the solar age was pointed out by Mr. G. H. Darwin in the following words:[46]

> Knowing, as we now do, that an atom of matter is capable of containing an enormous store of energy in itself, I think we have no right to assume that the sun is incapable of liberating atomic energy to a degree at least comparable with that which it would do if made of radium. Accordingly, I see no reason for doubting the possibility of augmenting the estimate of solar heat as derived from the theory of gravitation by some such factor as ten or twenty.

In conclusion, it is very evident that, however unpleasant it may be for the older men to revise their theories to meet the demands of new observations, we have in radio-activity the entrance into a region of new knowledge which will cast light upon many a dingy avenue of philosophy. Great are the trials and great the final triumphs of experimental science.

In Norse mythology there is a wonderful tree called Igdrasil, whose branches spread over the whole earth and reach up into the clouds. At the foot of the tree, away down at the deepest root, is a well from which the tree draws its sap. To us of the twentieth century that tree symbolizes science. The well which nourishes the tree is the fountain of eternal truth.

[46] *Nature*, Vol. 68, 1903, p. 496.

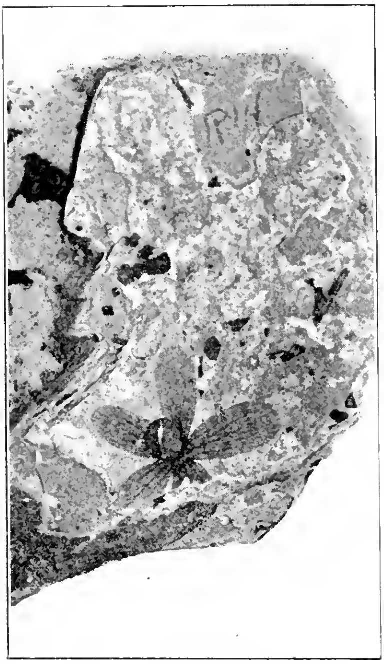
FLORISSANT; A MIOCENE POMPEII

By Professor T. D. A. COCKERELL

UNIVERSITY OF COLORADO

IN attempting to trace the evolution of plants and animals, the naturalist finds himself continually regretting what is called "the imperfection of the geological record." Of all the creatures which have lived and died upon the earth, only a very small proportion have left any record in the rocks; and since the remains are widely scattered and belong to very diverse periods of time, anything like a complete consecutive series is usually unattainable. It is somewhat as though the student of languages of some future age might be obliged to depend for his knowledge of the English tongue upon small fragments of the pages of Webster's Dictionary, perhaps about an inch square for each page. He would gather his precious scraps together, and by diligently comparing them, would readily deduce a number of things about the construction of the language. He would feel able to restore, in some measure, a certain proportion of the missing words, forming derivatives according to the rules he had been able to ascertain. But how he would long for a single complete page!—for a single series actually presenting to him the different modifications and amplifications of some root in all their richness and variety.

Each year witnesses an increasing number of paleontological discoveries, so that the incomplete series in our museums are gradually becoming more complete and more representative of the actual course of evolution. In some well-known instances, such as those of the horse and elephant groups, the successive stages are now so well known that it is not very difficult for imagination to supply the connecting links; but in others the record is either a total blank or a miserable scrap merely sufficient to awaken curiosity. Take, for instance, the butterflies. According to Dr. D. Sharp, the living species of butterflies known to science number about 13,000, while it is not impossible that 30,000 or even 40,000 actually exist. Butterflies form such a large and varied group, spread over nearly every part of the world where vegetation grows, that it is certain that they have a long history behind them, and that the total number of forms which have existed must run into the hundreds of thousands. Yet the actual number of fossil butterflies so far discovered is only twenty-two! Even this meager figure is in a sense an exaggeration, inasmuch as many—indeed most—of the



Fossil Calyx of *Porana tenuis*. (The genus is now Asiatic.)

species are only partially known from very incomplete fragments. The paleontologist and the historian not only desire to know how successive events are related, but are keenly alive to the necessity for detailed information concerning the contemporaneous events and objects of any one period. Hence it is that the uncovering of Pompeii and Herculaneum stirs the blood of the most lethargic, for there is presented to our gaze the actual life of nearly two thousand years ago in all its detail and variety. We know, perhaps, that the ancients had certain customs, used certain tools, enjoyed particular kinds of art and literature; but to accurately restore their daily life, even with the aid of many brilliant descriptive passages left by their writers, was a difficult feat for the imagination. To find two cities buried just as they stood at the beginning of the Christian era is not merely to gain an incalculably precious insight into the life of that period, but to obtain a landmark of the utmost service for comparisons, both with earlier and later times.

For like reasons, the naturalist may well look for earlier deposits in which living animals and plants are preserved somewhat as at Pompeii; and may feel thankful if in all the world one or two such places exist.

The most famous of such localities is Œningen, on the north or Baden side of a narrow arm of Lake Constance leading to the Rhine. The products of this wonderful fossil-bed—or rather, succes-

Fossil Land Snail (*Vitrea fagalis*). (Enlarged.)

sion of fossil-beds—have been principally elucidated by Heer, who was professor at the University of Zurich, and for many years the leading authority on fossil plants and insects. There were found more than 450 different kinds of plants, over 470 species of insects, and many fishes, reptiles and other animals. In America the corresponding locality, much more recently discovered, and much less extensively worked, is Florissant, in Colorado.

The first notice of Florissant as a locality for fossils was given by Mr. A. C. Peale in the "Annual Report of the U. S. Geological Survey of the Territories," in 1874. It was remarked that in the upper part of the valley on the South Platte River, a few miles from Pikes Peak, there was an ancient lake basin, marked by extensive deposits in which were found remains of leaves. In the years following, the place was visited by various naturalists, several of whom made collections. In 1877, Dr. S. H. Scudder, accompanied by Messrs. Arthur Lakes, of Golden, Colorado, and F. C. Bowditch, of Boston, spent the summer there, and made an enormous collection, especially of fossil insects. Mrs. Charlotte Hill, a resident of Florissant, also became interested, and with the aid of the neighboring children gathered together many valuable specimens, which are now to be found in various museums. An expedition from Princeton University, including the well-known paleontologists, W. B. Scott and H. F. Osborn, also went to Florissant, and the collections obtained were in part sent to the British Museum, and probably to other institutions. Another large collection was made by Dr. G. Hambach, of St. Louis, Mo., forming the basis of a paper on the fossil flora by Mr. W. C. G. Kirchner.

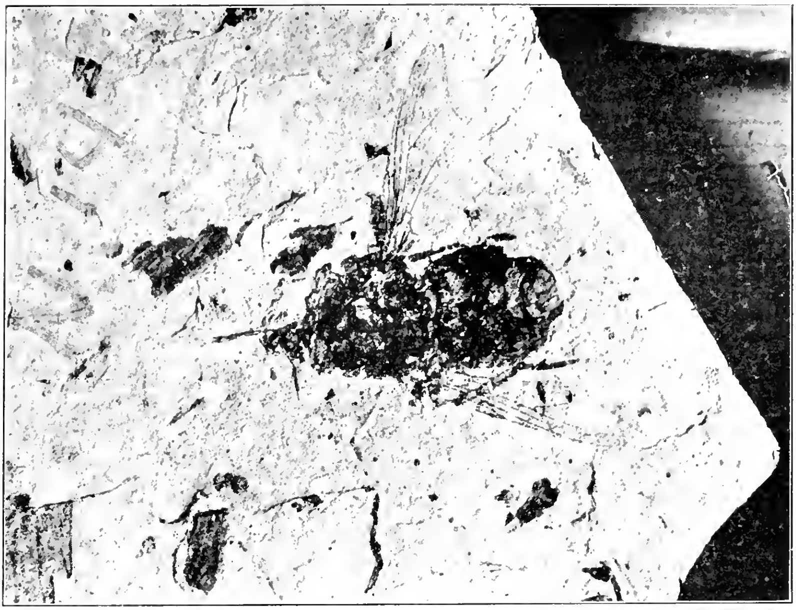
After a period of activity lasting a number of years, interest in Florissant died down, and not only were the fossil beds neglected, but hundreds of precious specimens already gathered were allowed to remain hidden away in various museums and colleges unstudied. When the material first came in, all the fossil plants were referred to Leo Lesquereux, who was at that time the one great authority on paleobotany in this country. Lesquereux published many descriptions of Florissant plants in his great works on the "Tertiary Flora" and "Cretaceous and Tertiary Floras," issued in sumptuous form by the U. S. Geological Survey in 1878 and 1883, respectively; while Dr. Scudder took charge of the insects, and wrote several very important monographs, the largest being that on "Tertiary Insects," published by the Geological Survey in 1890. When Lesquereux died, and later Dr. Scudder was incapacitated by paralysis from doing any further work, it was natural that Florissant should be neglected, for these two men were almost the sole authorities upon the subject. Furthermore, although the Geological Survey had in former years used funds for the Florissant work, and in particular had published the results at great expense, the fact that the latter were of no obvious value to the mining or kindred interests led to a withdrawal of financial support. That the restoration of the past—the discovery of the conditions which obtained in Colorado perhaps a million years ago—is of no value to mankind is a proposition which would scarcely be endorsed by any scientific man; but the fact remains that our present-day public makes a stronger demand for cash than for philosophic illumination, and the latter must often wait.

In the summer of 1905 the Florissant work was taken up anew by the University of Colorado, and Judge J. Henderson and Dr. F. Ramaley, of that institution, went there and collected a quantity of material. In 1906 a new expedition, consisting of Dr. W. M. Wheeler, of the American Museum of Natural History, and Mr. and Mrs. Cockerell and Mr. S. A. Rohwer, of Boulder, Colorado, spent a considerable time excavating fossils; and in 1907 the work was carried on still more extensively, with the financial cooperation of the American Museum of Natural History, Yale University, the British Museum and the University of Colorado. As a result, there has accumulated an almost embarrassing amount of material, and many remarkable things have been discovered.

Florissant is to-day a small town on the Midland Railroad of Colorado, about as far west of Pikes Peak as Colorado Springs is east of it. It is situated in an open valley or "park," surrounded by low hills, and consisting mainly of rather barren grass-land, with moister and even swamp areas along the creeks. The altitude is about 8,000 feet, and is far above the zone of oak bushes which forms such a conspicuous feature in the vicinity of Manitou. The hills are clothed with an open forest of conifers, mostly pines, and owing to the dry and sunny character of the locality, some of the southern plants, such as the Spanish Bayonet or Yucca, grow in abundance. The town itself is small, and exists principally for purposes connected with the railroad; it is a shipping point for a certain amount of lumber, but in no sense a mining center.

In ancient times—say about a million years ago—the valley was the site of a beautiful lake—Lake Florissant. This body of water was perhaps about nine miles long, but very narrow, and strongly indented by wooded headlands at every point. Here and there were small islands, upon which grew tall redwood trees and other vegetation. It was just such a place as would have delighted the heart of Fenimore Cooper and his hero of the Leatherstocking tales. The climate was very different from that of modern Colorado; mild, warm and damp, not unlike that of the uplands of our southern states. Yet the hills were probably rather dry, for we find remains of plants suited to diverse ecological conditions, from semi-arid uplands to swamps. Not far away vapor and fumes arose from several volcanic vents, and at frequent intervals there were showers of fine ash, while more rarely molten lava escaped and flowed down the slopes into the lake. During the larger eruptions, as has been recently witnessed at Martinique, there were violent gusts of wind, and blazing cinders of various sizes fell on all sides. Green branches were torn from the trees, and are found with the leaves still attached in the shales; while many leaves are burned and torn, and an abundance of charcoal testifies to the existence of forest fires. The clouds of fine ash bore to the ground all winged insects and, when falling in the shallow water of the lake, gave rise to layers of soft mud and sand, which, under the pressure of subsequent deposits, solidified into rock. In this way the shales were formed, the best being under heavy flows of mud or lava, which compressed them and permitted the preservation of the remains they contained, before decomposition had gone too far. Within a limited area hot waters strongly charged with silica surrounded and bathed the remains of the redwood trees, with the result that these are now wonderfully preserved as fossil stumps, one of them of great size.

In the course of ages, after the lake had disappeared, the streams flowing through the valley cut out the soft shales and carried them in fine particles to the Platte River, whence they found their way toward the plains. It is sad to think of the thousands of magnificent fossils which must have been thus destroyed—the infinitesimal fragments of which are now scattered far and wide over the Colorado plains, or have traveled perhaps to the Mississippi and the sea. The result of all this destruction, however, has been favorable to the paleontologist in this sense, that it makes the shales readily accessible at many points. Along the sides of the valley, close to the old shore lines, the fossil-bearing layers are plainly visible, and no doubt those which are preserved are far richer than were those which occupied the middle of the lake. The amount of the deposit still remaining is not known, but it must be very great, so that its possibilities could not be more easily exhausted than those of Herculaneum. Only a few places have been worked for any length of time, while small outcrops, inviting investigation, are very numerous. The work of uncovering the fossils is necessarily very slow. First of all, the heavy cap of solid rock has to be removed—and the farther one goes into the hillside, the greater it is—and then the shale has to be split with a knife into fine layers, often with great difficulty. With the utmost care, it is certain that many things will be lost, either from not being observed when uncovered, or from the shale not splitting in the right places. It would not be practicable to have the work done by untrained laborers, with the exception of the preliminary digging and shoveling, for they would destroy and lose far more than they found. Frequently the most precious and perfect insect remains are



FOSSIL TSETSE FLY (*Glossina oligocena*). The tsetse flies are no longer found in America. (Much enlarged.)

scarcely visible at all, especially on the wet shale as it is dug out; but under a strong lens they show every detail of the structure of the wings. On the other hand, some specimens which superficially appear excellent prove upon minute examination to be of small scientific value.

When the fossils have been obtained, it is no easy matter to determine and describe them. In the case of the plants, many species are easily recognized and can be classified with much certainty; but there are living species of oaks and maples, for example, which possess foliage wholly unlike that which we usually associate with those names. A maple from Japan, judged by its leaves, would be taken for a hornbeam; some oaks resemble willows. The commonest leaf in the shales was considered by Lesquereux to be allied to the water elm of the southern states; but we have found some pieces with the fruit attached, and it seems to be a beech. Calyces, once supposed to belong to persimmon or some allied plants, prove to be those of a poplar; while the giant redwood itself was first introduced as a moss, from a fragment of a twig!

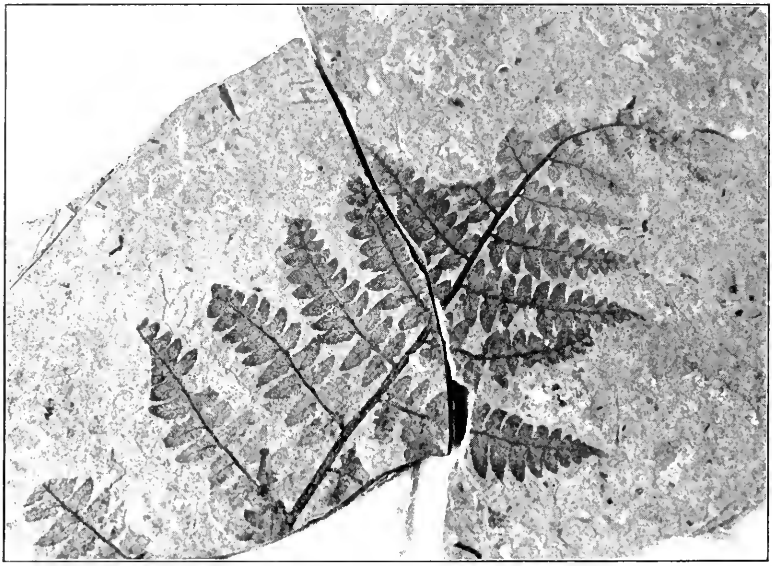
The insects, when well preserved, offer much better characters than most of the plants. Unfortunately, however, they are frequently indistinct or fragmentary, and the accurate determination of the remains becomes extremely difficult. Only those who have worked on fossil insects can appreciate at their proper value the tremendous labors of Scudder, resulting in the description and classification of many hundreds of species. Sometimes very striking structural characters may be observed; but when assistance is sought from the literature on living forms, the student finds that characters of this class have been ignored, and it is necessary to make a fresh study of the modern genera before proceeding with the fossils. In order to do this, however, large collections are needed, and it is no easy matter to secure sufficient specimens. Thus, in one way and another, the opportunities for error in the study of fossil insects and plants are very many; so many, that it is easy to become discouraged, and yield to the temptation to confine oneself to the comparatively easy problems presented by modern types. In such times of discouragement, however, the student may be cheered by the discovery of some splendid thing, telling a tale beyond dispute; and so he returns to his labors, determined to unravel the secrets of the past, and to accept as philosophically as may be the inevitable results of his inability to avoid a certain percentage of error.

In an effort to reconstruct the landscape of the Miocene period in Colorado, we may well begin with the plants. The number of fossil plants described from Florissant is not nearly so great as that from Œningen; but the deposits of the latter locality are, apparently, not so nearly contemporaneous; while, on the other hand, not nearly all the Florissant species that have been found have yet been published. The collections of the 1907 expedition, rich in new materials, have only

Fossil White Ant (*Hodotermes coloradensis* of Scudder).

recently been unpacked, and their study has scarcely more than begun.
The shores of the lake, while doubtless steep in places, must have sloped gradually at many points, and there was much shallow water. In this grew the broad-leafed cat-tail of those days, the *Typha lesquereuxi.* The remains of its leaves are found in the greatest abundance and upon some of them it has even been possible to detect a fungus, which has been called *Didymosphæria betheli.* In the water near the bases of the cat-tails was a duckweed. Water lilies have not been found; a round water-lily-like leaf proves to belong to a semi-aquatic plant, a kind of frog's-bit. A small rush, a species of *Juncus,* scattered its fruits everywhere. Small fresh-water molluscs, similar to those of the present day, abounded. There were bivalved forms (*Sphærium*), and representatives of the pond snails *Lymnæa* and *Planorbis.* Dragon-fly and May-fly nymphs were excessively numerous, especially the latter; while the adult insects flew along the shore. Minute bivalved crustacea were in myriads, but no crayfishes have been detected, and there is no reason for supposing that any existed. In slightly deeper water, there were innumerable fishes, and well-preserved specimens of several species have been obtained. From the fish specimens actually secured, one might suppose that these animals were comparatively rare; but this idea is contradicted by the abundance of their excrement, often containing ants and other insects which may have been killed by the volcanic fumes or ash. It would seem, indeed, that at the beginning of an eruption, the fishes gorged themselves with the falling insects; but when things got too hot for them, they mostly retreated in safety to deeper waters, where they escaped entombment. No frogs or turtles have been obtained, much to our disappointment; it is hardly to be supposed that there were none—we may rather anticipate that they will be unearthed by some happy collector of the future. Near the shores, the principal trees were the narrow-leafed cottonwood—differing little from the one common in Colorado to-day—a kind of beech, *Fagus longifolia,* and a *Myrica* with slender twigs, which may not have been more than a shrub. A little more distant from the water, perhaps, were the redwoods, *Sequoia haydeni,* very like those growing in California at the present time. Under or near the redwood grew the incense cedar, a tree now confined to the Pacific coast (where it still grows with *Sequoia*) and China, though a closely allied genus occurs in the southern hemisphere. There were no firs or spruces, but two or three species of pine trees were plentiful, probably upon the tops of the little hills; and a shrubby or tree-like juniper—like the so-called cedar of modern Colorado—was a conspicuous object. The warmth and dampness of the climate are indicated by an abundance of ferns, such as may be seen in the forests along the Hudson at the present time. Indeed, the whole aspect of the country must have been

much more like that of the forest region of the eastern states than any part of Colorado to-day. After working at Florissant in the summer of 1907, I had occasion to spend some time at Garrison-on-Hudson, and as I daily went through the splendid woods of that region, it seemed to me as if the flora of the shale had come to life. There was the sweet fern, *Comptonia*, to-day confined to a single species of the eastern United States; in Miocene times wide-spread, and represented by two kinds at Florissant. There was the large-toothed aspen; leaves with even larger teeth, but very similar, were found in the shales. Then the chestnut—great chestnut leaves, of an undescribed species, were among the best of our finds. So also the basswood, the walnut, the ironwood, elm, hickory, holly and many other trees, now wholly



FOSSIL FERN (*Phegopteris guyottii*).

absent from Colorado, but common to the Miocene shales and the eastern states. One of the most interesting of the fossils is the sweet-gum, or *Liquidambar*: a genus widely dispersed in the Miocene, from America to Europe, while now its few scattered remnants are found in our Atlantic coast region, in Mexico and Central America and in Asia. On the other hand, the existing Rocky Mountain flora is represented in the Florissant shales by species of oak, alder, birch, hackberry, barberry, mock-orange or Philadelphus, maple, gooseberry, grape, rose, hawthorn, mountain ash, willow, Virginia creeper, sumach and a number of others, showing that with all the change of climate which has occurred, the flora has not been totally transformed.

No recognizable mammal has been obtained at Florissant; only a

FOSSIL SOAPBERRY TREE (*Sapindus stellariæfolius*).

few fragmentary remains, without a skull. There is no doubt that mammals of many kinds abounded in the vicinity of the lake, and it is very likely that some of them were entombed, their bones waiting to be exhumed by some fortunate paleontologist of the future.

Feathers are occasionally found, and two fairly complete birds have been discovered, one a plover, the other apparently a finch. The fishes already mentioned number eight species. Of molluscs, we know two terrestrial species and four or five fresh-water ones. Thirty different spiders have been described by Scudder, and we have found others. The harvest spiders or phalangids, and the millipedes, are each represented by a single kind. It is for the insects, of course, that Florissant is most famous, surpassing even Œningen.

Mr. Scudder wrote:

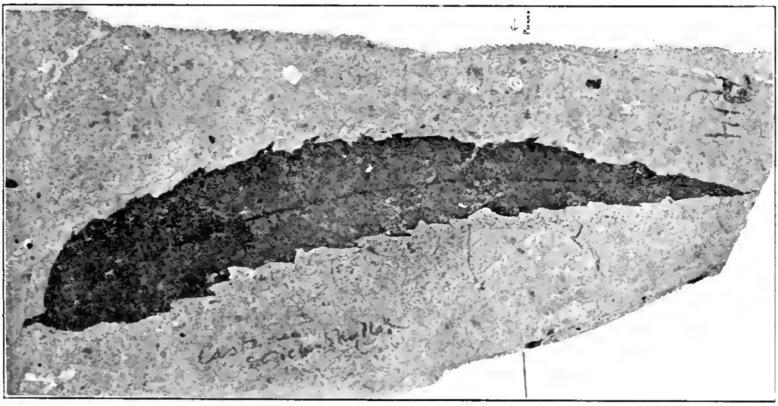
> The insects preserved in the Florissant basin are wonderfully numerous, this one locality having yielded in a single summer more than double the number of specimens which the famous localities at Œningen furnished Heer

in thirty years. Having visited both places, I can testify to the greater prolificness of the Florissant beds. As a rule the Œningen specimens are better preserved, but in the same amount of shale we still find at Florissant a much larger number of satisfactory specimens than at Œningen, and the quarries are fifty times as extensive and far more easily worked.

The total number of species of insects so far described from Florissant is about seven hundred, but several hundreds have been found, belonging to groups not yet worked up. The list, as it stands, contains only a single ant, but, as a matter of fact, ants are much more abundant than any other insects, at least in individuals. Those obtained by Scudder, and also the materials secured by the recent expeditions, are all in the hands of Dr. W. M. Wheeler, of the American Museum of Natural History. His account of them will be of extraordinary interest, based as it will be on the examination of thousands of specimens by a naturalist fully competent to make them contribute, not

Fossil Incense Cedar (*Heyderia coloradensis*) with small piece of redwood (*Sequoia haydeni*). (Enlarged.)

merely to the science of myrmecology, but to wider biological theories as well. It is, indeed, through the examination of myriads of specimens representing particular periods in the history of the world, that we may expect to solve some of the most difficult questions of evolution. Scudder noticed that among certain of the groups of fossil insects there were particular tendencies observable throughout, notwithstanding the fact that the species belonged to different groups. Legs had grown longer, or wing-cells had shortened, since the Miocene, and different series, already at that time quite separate and free from crossing, had been affected in the same manner. The same sort of thing was later remarked by Professor Osborn in the teeth of extinct animals, and he became convinced that there were fundamental predispositions to vary in particular directions. Theories of this sort, if completely verified,



Fossil Chestnut Leaf (*Castanea dolichophylla*). Close to the leaf is also seen a small freshwater shell (*Planorbis florissantensis*).

would greatly affect our ideas of the process of evolution; but the chief need at present is for more light, derived from more and more diverse groups of animals. Hence the study of the fossil insects, at first seeming of purely entomological interest, is likely to lead to results of the first importance.

While we thus search for trends of evolution, we note also the great conservatism of insect types. It is well known that warm-blooded animals have undergone great changes since the Miocene, one of them being the evolution of man himself. In the case of the insects, however, the modifications have been slight indeed, even where these have been driven far and wide by adverse changes of climate.

We find, it is true, a fair number of extinct genera; types which no longer persist in the modern world; but these appear to be merely those which have died out, not the ancestors of any modern kinds. None of the species, of course, are supposed to agree with living ones; but most of the genera agree well, except in certain groups, like the plant lice, in which there is a similar divergence throughout.

Owing to this singular constancy of fundamental structure, we are able to ascertain that some striking types now confined to particular parts of the world, were once very widely spread.

Perhaps the most remarkable instance of this sort is afforded by the tsetse fly, *Glossina*. Scudder obtained from Florissant an imperfect specimen of a large fly, which he regarded as representing a new genus and species. We were so fortunate as to secure a much better example, showing the long proboscis, and it was not difficult to recognize it as a veritable tsetse fly. The species, of course, is extinct; but the genus is the same as that now confined to Africa, where it is dreaded as the disseminator of some of the most terrible diseases known. What part the existence of such flies may have played in the destruction of the Tertiary mammalia we can only surmise; but it is not impossible that their influence was great. How it happened that they disappeared entirely from America and survived only on the Ethiopian continent is, of course, unknown.

Another discovery, hardly less interesting, was a species of Neuroptera belonging to the family Nemopteridæ. These insects are very fragile and delicate, somewhat dragon-fly-like in form, but with the most extraordinary hind wings—consisting of a long narrow stalk, with a dark-fiddle-shaped expansion at the end. One species of this family has been found in Chile, while others are known from the warmer parts of the old world. The whole group has become extinct in North America, but the fossil proves that it once existed there. Such a fossil as this not merely throws a flood of light on the past migrations of a peculiar group, but is the first and only indication we have of the past history of its race.

Florissant is famous for its fossil butterflies, having nearly half of the number known in that condition. My wife was particularly anxious to find a fossil butterfly, and often as we went out to work, we asked, would this be the day to yield the coveted treasure? Yet all the first season passed, and no butterfly was obtained. Toward the close of the second season, however, my wife sat down one day at a new place, to see what it might be worth. She had scarcely begun to turn over the shale when, behold, a truly magnificent specimen! It showed the upper wings, the body and one antenna, the spotting still plainly visible upon the wings. It proved to be an undescribed species, but of a genus still existing in Colorado, though more common southward. When compared with the Scudder collection, it was seen to be the second finest of the butterflies, yielding place only to Scudder's in-comparable *Prodryas persephone*. During the same season we secured a second butterfly, much larger, but very poorly preserved.

When the fine butterfly was discovered, it was naturally expected that the new locality would yield other like treasures. Alas! it was worked all one day, with practically no result. Such are the fortunes of fossil hunting. While the first season yielded no butterfly, it did produce a wonderfully preserved caterpillar, still showing the bristles it bore in life. It is not the usual custom to describe a lepidopterous insect from the caterpillar alone; but in this case we had no option, since it could not be ignored, and it certainly could not be raised to maturity! Its characters were peculiar, so that it did not fit comfortably into any modern family, so far as we were able to judge.

Fossil Neuropterous Insect (*Halter americana*) of a Family not now found in North America. (Much enlarged.)

Among the plants, one great treasure was a branch of the narrow-leafed cottonwood, with about ten leaves upon it. Although the leaves of this tree are exceedingly common in the shale, such a magnificent specimen is very rarely obtained. During the second season another nearly as good was found; we packed it up with the greatest care, and sent it by express to Yale University Museum, where it arrived in safety.

The large specimens, however, are not necessarily the most valuable. One small but unique object was a tuft of moss, with the fruiting bodies upon it. This was the first really recognizable moss ever found fossil in America, and it was appropriately transmitted for study to Mrs. Britton of the New York Botanical Garden, the best authority on American mosses. It may now be seen in the great Botanical Museum in Bronx Park.

Flowers and fruits are quite numerous in the shale, though, unfortunately, nearly always detached from the plants, so that they can not be correlated with the leaves. Some of them are very well preserved and easily recognizable; others, even though reasonably perfect, have puzzled all the botanists who have examined them. One curious specimen is a bean pod, with most of the beans still in it, but one just in the act of falling out. Grass-seeds are often found, and we have one which had just begun to sprout when it was overwhelmed by a fall of ash.

CRIMES OF VIOLENCE IN CHICAGO AND IN GREATER NEW YORK

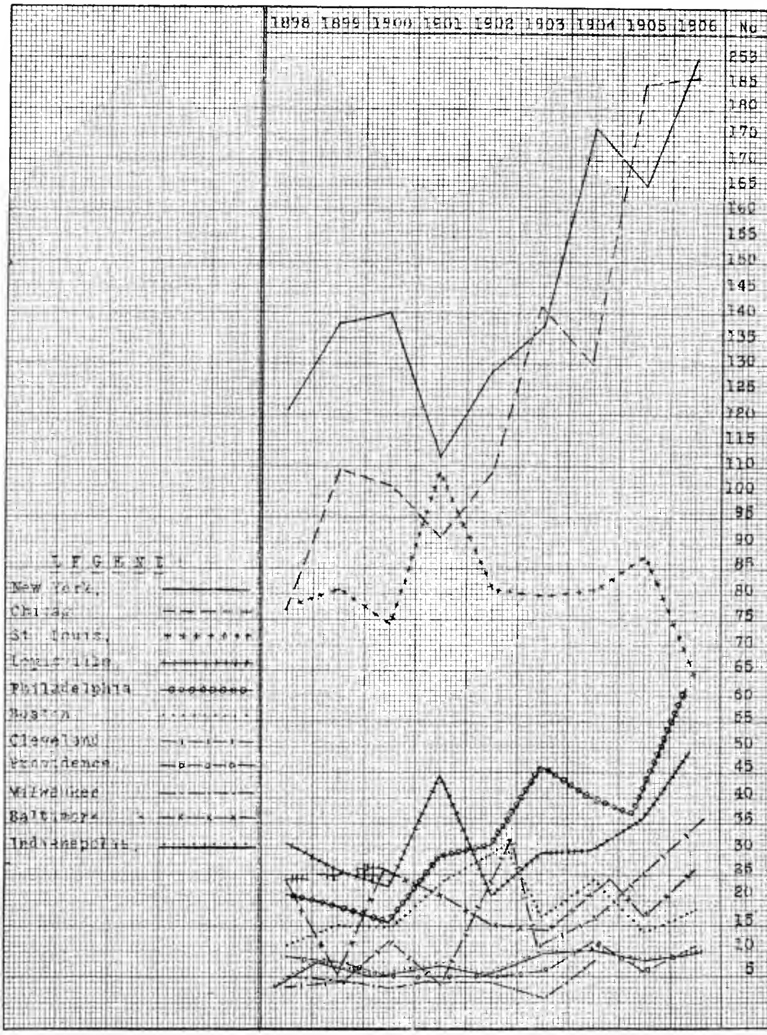
BY MAYNARD SHIPLEY
RENO, NEV.

"HUMAN life is the cheapest thing in Chicago," recently declared Judge Cleland. "This city," he asserted, "witnesses a murder for every day in the year." Now 365 homicides a year would mean, for Chicago, that one out of every 5,614 of her citizens is destined to be murdered each year; or, in other words, that 17 in each 100,000 of the population would annually meet death at the hands of a fellow citizen. This would place Chicago on a criminal level with Lexington, Ky., where nearly 39 per cent. of the population are negroes. In Chicago the negro element forms scarcely 2 per cent. of the total inhabitants. As a matter of fact, however, whereas Lexington stands first in the scale of American cities in respect to the ratio of deaths by homicide to total population, Chicago stands about eighth in the list, showing a lower record for homicides than either San Francisco or Los Angeles, as may be seen in the accompanying table.

TABLE SHOWING THE ANNUAL AVERAGE OF DEATHS BY AND ARRESTS FOR HOMICIDE IN EACH 100,000 OF POPULATION, IN VARIOUS CITIES OF THE UNITED STATES, BASED ON REPORTS OF HEALTH OFFICERS AND OF CHIEFS OF POLICE. (Most of the averages given are for a period of six years.)

City	Annual Average of Deaths by Homicide per 100,000 of Population	Annual Average of Arrests for Homicide per 100,000 of Population
Lexington, Ky.	17.77	40.07
Kansas, Kan.	17.64	18.27
Louisville, Ky.	14.85	17.41
Cincinnati, O.[1]	14.28	6.9C
St. Louis, Mo.	14.16	11.30
San Francisco, Cal.	9.25	19.69
Los Angeles, Cal.	9.00	4.86
Chicago, Ill.	7.30	6.87
Cleveland, O.	6.12	9.56
Greater New York	4.93	13.23
Indianapolis, Ind.	4.18	4.74
Providence, R. I.	3.59	1.70
Baltimore, Md.	3.39	7.74
Philadelphia, Pa.	3.27	4.93
Boston, Mass.	3.13	1.98
St. Paul, Minn.	2.32	2.13
Newark, N. J.[2]	1.50	9.16
Milwaukee, Wis.	1.45	1.77

[1] As the Census estimate of population is too low, the ratio of deaths by homicide is proportionately too high.
[2] Probably incomplete returns on number of deaths by homicide.



The annual average ratio of deaths by homicide in Chicago, as given in the table, is, for the six years 1901–06, 7.30 per 100,000 of inhabitants. The minimum for these years was 5.23, in 1901; the maximum was 9.26, in 1905, the ratio for 1906 being 9.17. The maximum for San Francisco was 11.90, in 1902; and for Cleveland, 8.57, in 1906. From these figures it may be seen that the "carnival of crime" in Chicago, in 1906, did not by any means place the Windy City in the lead as a "Scarlet City." While it is true that crimes of violence are increasing in Chicago faster than the growth of population, the augmentation has been gradual, and no greater, relatively, than in Philadelphia, Cincinnati, Cleveland, Louisville, Los Angeles

Annual Number of Deaths by Homicide in Various Cities during Nine Years—1898–1906

	1898	1899	1900	1901	1902	1903	1904	1905	1906
New York	121	137	140	112	127	137	176	165	253
Chicago	77	108	102	92	108	142	130	185	187
St. Louis	78	81	74	109	82	80	82	87	63
Louisville	32	26	23	44	22	29	30	36	48
Philadelphia	22	18	16	28	32	46	40	37	62
Boston	12	15	15	23	31	17	24	14	18
Cleveland	3	4	12	4	32	11	16	24	36
Baltimore	24	5	26	21	15	14	24	17	26
Indianapolis	3	8	5	7	5	9	10	8	10
Providence	9	8	5	5	5	6	12	6	11
Milwaukee	5	4	3	4	4	2	8	?	?
Los Angeles	?	?	?	?	12	9	11	24	20
Lexington	?	?	?	4	4	6	5	6	6
Newark	?	?	?	?	5	3	5	3	9
St. Paul	?	?	1	10	1	5	6	6	1
San Francisco	27	32	?	?	43	36	?	?	?

and many other cities. If the number of homicides, in proportion to population, was much higher in 1905 and in 1906 than in 1901 and 1902, such an increase is by no means unprecedented, nor are such annual variations from the average unusual either in Chicago or elsewhere. Already in 1888, the proportion of murders to the number of inhabitants was almost as "alarming" as in 1905, and the ratio was even then higher than it was to be as late as 1903, being 8.09 in the year 1888, and but 5.88 in 1902. As late as 1904 the ratio was only 6.72. Again, while the ratio was 9.17 in 1906, it was 8.38 as far back as 1893, and 7.24 in 1886, which is just about equal to the average for the six years ending with 1906. Taking a period of thirty-five years, the increase in deaths by homicide has been as follows: For the period 1872–79 (eight years), the annual average ratio was 3.20; for the thirteen years 1880–1892, 5.55; for the fourteen years 1893–1906, 7.19 homicides per one hundred thousand of population. The maximum ratio for any one year of the three periods was, 5.00 in 1873; 8.09 in 1888, and 9.26 in 1906. Of grave crimes in general, the increase of arrests was from an annual average of 243.0 per one hundred thousand of inhabitants for the three years 1901–03, to 269.1 for the three years 1904–06, an augmentation during the latter three years of 26.1 in each 100,000 of the population. This increase consists almost entirely of arrests for assaults with a deadly weapon and for assaults with intent to kill. There has been little or no increase in the proportion of arrests for burglary and robbery.

That the increase in crimes of violence in Chicago is due to the presence of a large foreign-born element of an inferior economic and social status is amply attested by the available statistics. For instance, the police records for 1905 show that whereas the ratio of arrests per

100,000 of population among native whites for murder and murderous assaults was 94.16, among the foreign white population the ratio was 146.65 per one hundred thousand. Among the negroes the ratio was 107.52.

In considering the above statistics, the fact should be borne in mind that the greater frequency of crimes of violence among certain elements of the foreign-born population does not imply an inherent and ineradicable viciousness or criminality among these unfortunate immigrants, but merely a lawlessness due to unfavorable environment and inadequate education, mental and manual. Crime is twin brother to poverty, and both are the children of ignorance and greed.

It may be said, in conclusion, that while crimes of violence have increased in Chicago during the past thirty-five years, the increase has not been so great as has been represented, and that the alarming reports sent out about the "carnival of crime" in Chicago are usually without especial significance, since crimes of violence occur in all great cities sporadically, generally in quick succession. At the end of the year it is found, as a rule, that no unusual increase for the twelve months has taken place, or that even an actual decrease has occurred, as was the case in Chicago during the year 1906.

For the past four or five years the American public has been startled by sensational reports regarding "the terrible increase of crime in New York City." The year 1906 brought the usual quota of comment and criticism. More recently the apparently unprovoked killing of a policeman by an Italian assassin has focused attention upon the fact that at least 1,600 of the foreign-born element of the great metropolis have been permitted to go about the streets armed with a deadly weapon. This evil practise is tolerated more or less in nearly all our great cities, and with the same disastrous results. New York, Chicago, Cleveland, Cincinnati, Philadelphia and other rapidly growing cities, nearly all show an increase in the proportion of crimes of violence commensurate with the changing character of their immigrant population.[1] But, contrary to popular opinion, the increase of homicide in New York City has been very slight during the past decade, the year 1906 excepted. This agrees with the fact that the racial composition of the population has not materially changed during the five or six years preceding 1905. Taking a longer period, however, we find quite an increase in the number of crimes of violence, especially assaults with a deadly weapon, and, apparently, murder and attempts thereat. In 1880, when less than ten per cent. of New York's alien population was drawn from Russia and southern Europe,

[1] The extent of this change was partially traced by the present writer in an article on "The Effects of Immigration on Homicide in American Cities," POPULAR SCIENCE MONTHLY, August, 1906.

with less than three per cent. from Italy, the number of arrests for the various forms (or degrees) of homicide was less than four in each one hundred thousand of the population. In 1890, when over 30 per cent. of immigrants were from Russia or southern Europe, there were nearly seven such arrests in an equal number of residents. In 1900, the percentage of aliens of this socially and economically inferior type had reached nearly seven tenths of the total volume of immigration, while the ratio of arrests on the charge of killing a fellow-man had increased to 13 per one hundred thousand of inhabitants. In 1906, the ratio rose to 21.51 per one hundred thousand of population. Meanwhile, in other large cities of the Empire State, such as Buffalo, Rochester and Syracuse, where the foreign-born population was derived almost entirely from northern Europe, no increase in the proportion of homicides to total population has been noted. In Syracuse there have been but six cases of homicide under jurisdiction of the police department in a period of fourteen years.

Annual Number, and Proportion per One Hundred Thousand of the Population, of Deaths by Homicide; and Annual Number of Arrests made for Murder, Manslaughter, Homicide and Infanticide, during the Nine Years 1898–1906

	1898	1899	1900	1901	1902	1903	1904	1905	1906
Arrests for murder, manslaughter, homicide and infanticide.	347	406	451	429	517	582	630	737	885
Deaths by homicide.	121	137	140	112	127	137	176	165	253
Deaths by homicide per 100,000 of population.	3.80	4.12	4 07	3.15	3.46	3.62	4.52	4.12	6.15
	For the Six Years 1898–1903						1904–06		
Annual average ratio per 100,000 of population.	3.70						4.93		

It is worthy of note that while the number of homicides in New York City has greatly increased during the past thirty-six years, there has been no increase, to speak of, in the ratio of convicts to total population, held in the state prisons for murder and manslaughter. In 1880, there were 5.50 in each one hundred thousand of the population held for murder or manslaughter; in 1890, 7.36; in 1906, 5.78 per one hundred thousand of population. This may be partly due to the fact that the police force of New York City, where about one third of the homicides of the whole state are committed, has grown steadily smaller relative to the growth of population. Coroner Peter B. Acritelli declares that "only one in ten murders and assaults is followed by arrests." Moreover, he states that, "Even when an arrest has been made, when the case comes to trial the Italian witnesses either mysteriously lose their memories or disappear until the trial is over." The Italian of southern Italy thinks there is something unmanly in an appeal to the law, and that it is the duty and privilege of every man to right his own wrongs.

While the police court records show an increase in the number of arrests for the various forms of homicide from 347 in 1898, to 517 in 1902, and to 885 in 1906, these figures do not represent a proportionate increase in the number of deaths by homicide, as may be seen by the accompanying table.

From the foregoing figures it may be seen that the ratio of deaths by homicide to total population was the same in 1905 (4.12) as it was six years earlier, in 1899; and that whereas the annual average ratio for the six years 1898–1903 was 3.70 per one hundred thousand of inhabitants, the average annual ratio for the three years 1904–06 was 4.93. Such an increase is hardly sensational. In the matter of the more serious crimes in general, such as robbery, burglary, arson, felonious assault and the various forms of homicide, taken altogether, the increase was from 120.9 per one hundred thousand of population, to 166.3 (in 1905); an increase of 45.4 in each 100,000 of inhabitants. The greatest increase to be noted is in the number of arrests for felonious assault.

That a large share of the more grave forms of criminality is perpetrated by certain elements of New York's alien population is easily demonstrated. Thus, of the 4,124 aliens held for grave crime in the penal institutions of the United States in 1904, one fourth were detained in the prisons of the empire state. It is also a significant fact that of the ninety-one persons who met death at the hands of a fellowman in the borough of Manhattan, in 1905, thirty-eight only were born in this country, and the parents of twenty of these were foreign-born. Of the 71 foreigners who were killed, twenty, or 28 per cent., were Italians, though eleven other nationalities were represented. Seven of the deceased were Chinamen (who are, in this country, more murderous in proportion to their numbers than the Italians); six of the deceased were Russians, five were natives of Ireland, four were Germans. No other nationality was represented by more than two victims. It is thus apparent how few of those murdered were native Americans of native-born parents. It is, perhaps, not too much to say that the lives of the better classes of citizens in New York City are as safe now as in previous decades, most of the deaths by homicide being confined to the immigrant quarters, the result of quarrels, of family or *tong* feuds, rather than of cold-blooded murder, for gain. Coroner

Peter B. Acritelli states that "Two thirds of the list of homicides in the Tombs are men of Italian birth." And doubtless nine tenths of these are from Sicily, Sardinia or southern Italy, since the natives of northern Italy are not given to crimes of violence; human life being safer in Venice or Florence than in Boston or Philadelphia; more secure in Milan, Turin or Genoa than in Cleveland, Chicago or San Francisco.

The accompanying table shows the comparative security of human life in various cities, and reveals the fact that the life of the average citizen is as safe in New York as in most urban communities.

TABLE SHOWING THE AVERAGE ANNUAL RATIO OF DEATHS BY HOMICIDE PER 100,000 OF POPULATION IN VARIOUS CITIES, BASED UPON OFFICIAL REPORTS

City	Annual Average of Homicides per 100,000 Population	Period
Mexico, Mex.	70.72	1899
Girgenti, Sicily	40.48	1897–1899
Sassari, Sardinia	38.64	1897–1899
Lima, Peru	36.60	1899–1900
La Paz, Bolivia	33.71	1902
Naples, Italy	29.23	1879–1899
Lexington, Ky.	17.77	1901–1905
Kansas, Kan.	17.64	1904–1905
Louisville, Ky.	14.85	1901–1905
St. Louis, Mo.	14.16	1900–1904
Rome, Italy	13.81	1897–1899
San Francisco, Cal.	9.00	1899–1903
Chicago, Ill.	7.03	1893–1904
Turin, Italy	6.56	1897–1899
Budapest, Hungary	6.13	1895–1901
Cleveland, O.	6.12	1904–1906
Genoa, Italy	5.83	1897–1899
New York, N. Y.	4.93	1904–1906
Providence, R. I.	3.59	1900–1904
Baltimore, Md.	3.39	1901–1905
Milan, Italy	3.20	1897–1899
Philadelphia, Pa.	3.27	1904–1906
Boston, Mass.	3.13	1904–1906
Venice, Italy	2.82	1897–1899
Newark, N. J.	1.50	1902–1904
Milwaukee, Wis.	1.45	1898–1904

In regard to the reputed increase of highway robbery in Greater New York, the police records would seem to show that no such increase has taken place. In comparing the number of crimes annually committed in New York City, it should be borne in mind that the population increases at the rate of nearly 113,000 yearly. As to the increase of highway robbery, the police court records merely show that the number of such crimes is far greater in some years than in others. This is true of all our great cities. We may note, for example, that there were thirteen times more arrests made in Baltimore for highway robbery in 1903 than in 1901; in Newark, there were fifteen times more arrests for this offense in 1902 than in 1900, though the average for a period of six years shows only a slight increase in any of our cities, years of frequent arrests on this charge alternating with few, or, as in Baltimore, in some years, none at all on this charge. The number of such arrests in New York in 1899 was nine, in 1901, thirty-four, followed in 1903 by nine only. As a matter of fact, New York is one of the few cities in the union which show an actual decrease in the number of arrests for highway robbery. The official records show that whereas the annual average of arrests on this charge for the six years 1898–1903 was 19.3, for the three years 1904–06 the average was 16.7. Meanwhile, the population of New York had increased by about one million inhabitants. Arrests on the charge of arson show a very material increase, from an annual average of 26.0 for the six years 1898–1903, to 35.2 for the three years 1904–06. Arrests on the charge of felonious assault increased from 1,480 in 1898, to 3,375 in 1906. A proportionate increase in crimes of violence has occurred in nearly all cities of the union whose rapid growth is largely due to immigration from southern Europe and Italy. On the whole, the increase has been greater in Philadelphia than in New York. Boston and St. Louis are the only large cities that show an actual decrease in the number of deaths by homicide.

The chief encouragement to acts of violence in all the cities which show an increase of felonious assaults and homicides is a deplorably inadequate police force. Despite the fact that the growth of most of our cities is due to the immigration of a socially inferior type of citizenship, the strength of the police force is, in proportion to population and extent of ground to be patrolled, becoming smaller each year. If crimes of violence are far less frequent in London, Paris and Berlin, it is also true that the police and detective forces of these cities are, relative to population, much larger. And what is more important still, those who are held responsible for efficiency and discipline are free from political interference and the domination of office-holders.

THE MOVEMENT TOWARDS "PHYSIOLOGICAL" PSYCHOLOGY. III

By Professor R. M. Wenley
University of Michigan

V

LOTZE'S (1817–81) career as an author opened in 1841, and his psychological contributions relevant to the present theme came to an end practically in 1852. Thereafter, save for a few articles,[1] he devoted himself to the elaboration of his highly significant philosophical system. He therefore antedated the work of Helmholtz. A prominent figure in the bitter controversy over vitalism and materialism (1847–60), he suffered grave misunderstanding; nevertheless, thanks to lapse of time, his psychological position admits of no doubt.

The son of a physician, Lotze entered the University of Leipzig to prepare for the paternal profession. Under the influence of Weisse he became interested in philosophy, and, upon graduation, qualified as *Docent* in both the medical and philosophical faculties. Till 1852 the studies proper to the former predominated, philosophy claimed him later, and his system represents more symptomatically than any other the stress resultant upon the cross-currents of modern thought. It is meaningful that he occupied successively Herbart's chair at Göttingen and Hegel's at Berlin.

In 1842 he took a decided stand, or even lead, in the vitalist controversy,[2] and also published his "General Pathology and Therapeutics as Mechanical Sciences." His "General Physiology of the Corporeal Life" appeared in 1851 and, in the next year, the work of importance for us now—"Medical Psychology, or Physiology of the Soul." Viewed in the perspective of cultural development, especially in Germany, his position seems to me quite evident. Here is his own statement of it:

> We have two kinds of scientific knowledge. We know, on the one hand, nature, the essence of the object studied; on the other hand, we know only the external relations that are possible between it and other objects. In the first kind of knowledge, there is a possible question of a *cognitio rei* only when our intelligence apprehends an object, not simply under the form of external being, but in an intuition so immediate that we are able, by our senses and ideas, to

[1] Cf. "Formation de la notion d'espace" in *Revue Philosophique,* Vol. IV., pp. 345 ff.; appendix to Stumpf's "Ueber den psychologischen Ursprung d. Raumvorstellung" (1873); "Metaphysik," Bk. II., Chap. IV.; "Grundzüge d. Psychologie" (posthumous).

[2] Leben u. Lebenskraft, in Wagner's "Handwörterbuch," 1842.

penetrate its peculiar nature, and consequently, to know what ought to be, according to its internal and specific essence, the order of such a being. On the contrary, the other kind of scientific knowledge, the external, *cognitio circa rem*, does not penetrate to the essence of things, but consists mainly in a clear and precise apprehension of the conditions under which the object manifests itself to us, and under which, in consequence of its variable relations to other objects, it is regularly transformed.[3]

Prior to Lotze's generation, philosophy had shaped scientific learning, leaving, at the same time, a large field open only to strict scientific treatment. In his person, science shapes philosophy, leaving, at the same time, a large field open only to strict philosophical treatment.[4] One is surprised that such a simple explanation should have escaped notice, and that a presentation of Lotze so fantastic—almost impertinent—as that of Ribot, for example, should have been perpetrated. Lotze's ability to see both sides of a problem, and his consequent sense for the limits of physiological psychology (which, in my humble judgment, remains completely justified still in essentials), provide the clue to his attitude. So, he really presents two kinds of psychology. One would investigate the factors, combinations and mechanism of consciousness; the other would consider the import of consciousness, and the end (if any) which it subserves in the universe. To understand the latter it is necessary to master his very subtle cosmology ("Metaphysics," Bk. II.). The former *is* physiological psychology, and has been presented more particularly in Bks. II. and III. of the "Medical Psychology." Here Lotze writes as a scientific man, and the "conception of a psychophysical mechanism" suffices; that is, physical, chemical and physiological causality rules. Thus, he regards "physiology of the soul as an exposition of the mechanical conditions to which, according to our observation, the life of the soul is attached."[5] "The conception of a psychophysical mechanism can be stated as follows: As ideas, volitions and other mental states can not be compared with the quantitative and special properties of matter, but as, nevertheless, the latter seem to follow upon the former, it is evident that two essentially different, totally disparate, series of processes, one bodily and one mental, run parallel to each other. In the intensive quality of a mental process the extensive definiteness of the material process can never be found; but if the one is to call forth the other, the proportionality between them must be secured through a connection which appears to be extrinsic to both. There must exist general laws, which ensure that with a modification (a) of the mental substance a modification (b) of the bodily substance shall be connected, and it is only in

[3] "Med. Psych.," Vol. I., p. 50.

[4] Cf. Rehnisch in *Rev. Philos.*, XII., 321 ff.; Achelis in *Vierteljahrs. f. wiss. Phil.*, 1882.

[5] "Kleine Schriften," II., p. 204.

consequence of this independent rule, and not through its own power and impulse, that a change in the soul produces a corresponding one in the body. . . . It is quite indifferent to medicine wherein the mysterious union of soul and body consists, as this is the constant event which lies equally at the bottom of all phenomena. But it is of the greatest interest to medicine to know what affections of the soul are connected in that mysterious manner with what affections of the body."[6] Accordingly, his phenomenal psychology was guided by competent knowledge of physics and physiology, the latter, as we must recall, being a subject which he actually professed. His speculative psychology, dealing with the mysterious union, falls within his philosophy.

The third book of the "Medical Psychology," which still conveys lessons to the physician, deals with subjects such as sleep, attention, emotion, the influence of the flow of consciousness upon secretion, nutrition, and instinct, and with abnormal psychology. The second book reviews the factors of self-consciousness, especially in the light of the relation between the physiological mechanism and the mind. It thus includes his most distinctive contribution to physiological psychology—the famous theory of "local signs." This is an integral part of his analysis of space-perception, one of the subtlest ever formulated. His latest presentation of it runs thus:

Let it be assumed that the soul once for all lies under the necessity of mentally presenting a certain manifold as in juxtaposition in space; How does it come to localize every individual impression at a definite place in the space intuited by it, in such manner that the entire image thus intuited is similar to the external object which acted on the eye?

Obviously, such a clue must lie in the impressions themselves. The simple quality of the sensation "green" or "red" does not, however, contain it; for every such color can in turn appear at every point in space, and on this account does not, of itself, require always to be referred to the one definite point.

We now remind ourselves, however, that the carefulness with which the regular position on the retina of the particular excitations is secured, can not be without a purpose. To be sure, an impression is not *seen* at a definite point on account of its *being situated* at such a point; but it may perhaps by means of this definite situation *act* on the soul otherwise than if it were elsewhere situated.

Accordingly we conceive of this in the following way: Every impression of color "r"—for example, red—produces on all places of the retina, which it reaches, the same sensation of redness. In addition to this, however, it produces on each of these different places, *a*, *b*, *c*, a certain accessory impression, α, β, γ, which is independent of the nature of the color seen, and dependent merely on the nature of the place excited. This second local impression would therefore be associated with every impression of color "r," in such a manner that rα signifies a red that acts on the point *a*, rβ signifies the same red in case it acts on the point *b*. These associated accessory impressions would, accordingly,

[6] *Ibid.*, I., pp. 193–97.

render for the soul the clue, by following which it transposes the same red, now to one, now to another spot, or simultaneously to different spots in the space intuited by it.

In order, however, that this may take place in a methodical way, these accessory impressions must be completely different from the main impressions, the colors, and must not disturb the latter. They must be, however, not merely of the same kind among themselves, but wholly definite members of a series or system of series; so that for every impression "r" there may be assigned, by the aid of this adjoined "local sign," not merely a particular, but a quite definite spot among all the rest of the impressions. The foregoing is the theory of "Local Signs."[7]

The best anatomical and physiological researches fail to reveal spatial order as inherent in sensation; and, even if this ignorance be due to the impossibility of following up the evolutionary regress, it is a real difficulty. Lotze therefore concluded that "localization in space belongs to the unconscious product of the soul's action through the mechanism of its internal states."[8] We gain a *field* of *vision* from an *ensemble* of local signs, and, as concerns tactile sense, the same thing happens, the functions of the corpuscles of touch being like those of the cones and rods of the retina in sight. As a result, our notion of the extended originates in a perception of *qualitative* differences, from which the mind, by its own power of transformation, constructs extensive relations. Later researches into the structure of the peripheral nerve terminations seem to confirm, rather than undermine, the hypothesis. That it is a typical example of the limitations of hypothesis Lotze acknowledged quite frankly. But he claimed, with justice, that it explained the actual phenomena better than any other theory. As a consequence, even if modified, it has been incorporated in physiological psychology, and, especially as regards vision and touch, must be reckoned with still.[9] To sum up—the point is this: Lotze held that every sensation, say, of color, was accompanied by an "accessory impression" of locality. The facts made it necessary to assume this "accessory impression." Now, just because it happens to be an assumption, it lies open to several interpretations. In other words, the principle of the hypothesis may stand, but opinions as to the way in which it may be read can differ widely. However this may be, more than any other psychologist, he has laid bare the numerous pitfalls surrounding the explanation of a psychological fact so obvious and common as space perception.

Nascent sciences present a certain family likeness in their life

[7] "Grundzüge d. Psychologie" (1881); Eng. trans. (from ed. of 1884), pp. 51 ff.

[8] "Med. Psych.," Bk. II., Sect. 294.

[9] Cf. "Elements of Physiological Psychology," Ladd, pp. 396 ff.; "Principles of Psychology," James, Vol. II., pp. 157 f.; "German Psychology of To-day," Ribot, p. 95 (Eng. trans.).

history. Commonly, they begin as special inquiries, somewhat off the traditional lines, in the science which bears close or closest affinity to the future discipline. Such movements continue lonely for a time, systematization being difficult or unattainable till many facts have been collected. To the point reached now we see this stage predominating in physiological psychology. Physics and anatomy, physiology and philosophy present special departures toward psychology, but a unification of the last still lacks. The final step must be associated always with the names of Gustav Theodor Fechner and Wilhelm Wundt (the latter more emphatically), who, building on the accumulations of their predecessors, at length brought the new science into formal shape.

Fechner (1801–87), like Lotze, studied medicine at Leipzig, where he became professor of physics in 1834. Like Lotze, too, he was an expert in philosophy. Both were "masters in the use of exact methods, yet at the same time with their whole souls devoted to the highest questions, and superior to their contemporaries in breadth of view as in the importance and range of their leading ideas—Fechner a dreamer and sober investigator by turns, Lotze with a gentle hand reconciling the antitheses in life and science."[10] In a fashion Fechner's psychology is more intimately connected with his philosophy than Lotze's, and his philosophico-psychological perspective offers points of strong contrast to Wundt's. Indeed, his definition of psychophysics—a term original with him—hints as much. "I understand by psychophysics an exact theory of the relations of soul and body, and, in a general way, of the physical world and the psychical world." Undoubtedly, the psychology may be disengaged from metaphysical entanglements, as Wundt said in his address on the occasion of the Fechner centenary.[11] But, after all, Fechner's panpsychism forms a motive force of his psychophysics, because, intellectually, he was a double personality.[12] His philosophical theory teaches a universal parallelism between the physical and the psychical. Or, as Nägeli, the botanist, has it:

Sensation is clearly connected with the reflex actions of higher animals. We are obliged to concede it to the other animals also, and we have no grounds for denying it to plants and inorganic bodies. The sensation arouses in us a condition of comfort and discomfort. In general, the feeling of pleasure arises when the natural impulses are satisfied, the feeling of pain, when they are not satisfied. Since all material processes are composed of movements of molecules and elementary atoms, pleasure and pain must have its seat in these particles. Sensation is a property of the albuminous molecules; and if it belongs to these, we are obliged to concede it to the other substances also. If the molecules possess anything even remotely akin to sensation, they must have a feeling of comfort when they can obey the law of attraction or repulsion, the law of their own inclination or aversion; a feeling of discomfort, however, when they are

[10] "History of Modern Philosophy," Falckenberg, pp. 601–2 (Eng. trans.).
[11] Cf. "Gustav Theodor Fechner," K. Lasswitz, p. 91.
[12] Cf. *ibid.*, p. 154.

compelled to make contrary movements. Thus the same thread runs through all material phenomena. The human mind is nothing but the highest development on our earth of the mental processes which universally animate and move nature.[13]

Fechner had worked out this fundamental theory ere he arrived at his psychological results. We find glimmerings of it so soon as 1835, in the attractive "Little Book on Life After Death," in the tract "On the Highest Good" (1846); enlarged views in "Nanna, or the Soul-life of Plants" (1848); while the system appears full-fledged in "Zend-Avesta, or the Things of Heaven and the Hereafter" (1851); in 1861 he returned to it in his book, "On the Soul Question," occasioned by contemporary materialism, and in "The Three Motives and Grounds of Belief"; and in 1879 he reaffirmed and restated the position in the remarkable volume entitled "The Day View and the Night View." The essence of his teaching may be summed up in the thought that the material or external world is a half-truth, a concession to the sensuous, rather than an explanation of the psychical;

However complicated our brains may be, and however much we may feel inclined to attach to such a complexity the highest mental properties, the world is unspeakably more complex, since it is a complication of all the complications contained in it, the brains among them. Why not, therefore, attach still higher mental properties to this greater complexity? The form and structure of the heavens seem simple only when we consider the large masses and not their details and concatenation. The heavenly bodies are not crude homogeneous lumps; and the most diverse and complicated relations of light and gravity obtain between them. That, however, the plurality in the world is also grouped, comprehended, and organized into unity does not contradict the thought that it is also comprehended into a corresponding mental unity, but is in harmony with the same.[14]

Consequently, the physical symbolizes the psychical. They are two faces of a single existence. Human research may, therefore, deal with the one or the other, and attain, as it has attained, great success. But the real problem centers in the relation between the two. Of this, physiological psychology is *the* science. You can, accordingly, pursue it *quâ* science, but you must never forget the larger setting in which it finds itself.

Proceeding to the psychology, then, note at once that Fechner envisages the problem rather as a physicist than as a physiologist. So, he suffers from his limitations, but gains in precision. Soul and body being a single existence, it is practicable to investigate their mutual functioning and to state the results as laws of nature, which, in turn, are no more than assemblages of observations concerning phenomenal

[13] Cf. "Die mechanische-physiologische Theorie d. Abstammungslehre" (1884).

[14] "Ideen zu einer Schöpfungsgeschichte," p. 106.

existence. Of course, a developed psychology would endeavor to extend this plan to the entire range of consciousness. Fechner, however, confines himself to a single fundamental point—the relation between stimulus and sensation as generalized in Weber's law; although, just as Lotze before him, he considers other questions in a most suggestive manner, such, notably, as the seat of the soul, sleep and reminiscence. In pursuance of his early conviction, that soul and body are but opposite sides of an identical existence (conscious), he took it for granted that their reciprocal action would be proportional. But this was belief, not science. Weber's work led Fechner to test the hypothesis, that the increase of physiological excitation holds the key to psychological changes. And his interest was stimulated by the fact that, if this could be proved accurately, his philosophy would benefit by so much indubitable evidence. Consequently, he was moved to verify Weber's law by numerous experiments, chiefly of a *physical* sort. Sensations of pressure and muscular effort, detected by the use of weights; sensations of temperature, determined by cold and hot water; sensations of light, handled by the photometer; and sensations of sound, observed by reference to falling bodies, all tended to confirm the same general relation between stimulus and the psychological event. Given what Herbart called a "threshold of sensation," and having fixed this as a constant for each class of sensation, Fechner found it possible to infer, by strict induction, that the intensity of the sensation is equal to the *proportion* of the stimulus, multiplied by the logarithm of the excitation, divided by the threshold of stimulus. In other words, we *can* obtain a formula for the *quantitative* relation of physical and psychological events considered as magnitudes. This formula, which provides a means of measurement, declares that the sensations increase proportionally to the logarithm of the stimulus.[15] As a law, Fechner affirms dogmatically that it applies for internal (psychological) states and, within limits, reasons for which can be given, for external (physiological or physical) conditions. The result was obtained by three methods. (1) The Method of Differences which are Just Observable. This means that the operator finds, first, the least greater or the least smaller stimulus which can just be sensed as different by the subject; and then proceeds to add increments to this, or, inversely to subtract increments from it, till the intensity or diminution come into clear recognition. Divide the sum of the initial and the altered stimulus and you arrive at the differential of sensibility. (2) The Method of True (Right) and False (Wrong) Cases. Here the operator applies two stimuli, which differ slightly, to the subject, and inquires whether the first is greater

[15] Cf. "German Psychology of To-day," Ribot, pp. 138 f. (Eng. trans.); "Outlines of Psychology," Külpe, pp. 164 f.; Ward in *Mind*, Vol. I. (old series), pp. 452 ff.; or in any standard psychology, *e. g.*, James or Wundt or Ladd.

or smaller than the second. The replies are recorded; the ratio of true judgments to the total number of judgments gives the measure of sensibility, and varies directly with it. (3) The Method of Mean Errors—or of Probability of Error. Given a stimulus, the subject is asked to add another just equal to the *datum*. He deviates more or less; the probable error of the adjustment, in its deviation from the known mean, affords the direct measure of sensibility. The last, so far as an amateur can judge, would seem to be the most important, because the most accurate procedure. As has been said, the resultant generalization holds within limits, upper and lower.[16] But this is just what one anticipates in any law of nature. And there is another, much more pertinent, question. Does the law apply to the relation between sensation and neurosis, or merely to that between neurosis and excitation? If the former, it is psycho-physiological; if the latter, it is no more than physiological or, strictly, physical. Now this raises precisely *the* fundamental problem: Are sensations measurable? And this, in turn, seems to me to depend upon the possibility of differentiating between sensation and perception (the *manner* in which we experience sensation). So far as I catch the present drift, the *central* difficulty remains *sub judice*. On the other hand, if one be prepared to accept the theory that I call "organicism"—the analogue on the metaphysical side of activism on the ethical, which declares that our whole experience can only be interpreted as a single vast organism, in which every part bears a relation at once of means and end to every other, it follows plainly, in my judgment, that, if not Fechner's law, then *some* law (possibly not yet known, but necessary all the same) must be operative; and, further, that this law, in certain of its manifestations, is capable of discovery and verification by psycho-physiological methods. You see we must not demand finality from a new science in the first generation of its formal career. At this point the most pitiable errors have been made both by critics and by advocates. The critic who insists that physiological psychology has nothing to tell is in far too big a hurry to judge; and the advocate who urges that physiological psychology can tell everything forthwith deposes his own subject from its hard-earned place as a positive science. It is fair to add, as opposed to my own view, that the greatest American psychologist, Professor James,[17] states (1) that "Fechner's originality consists exclusively in the theoretic interpretation of Weber's law" (p. 545); (2) that "the entire superstructure which Fechner rears upon the facts is not only seen to be arbitrary and subjective, but in the highest

[16] Ribot, *q. s.*, p. 168; Helmholtz, "Physiol. Optik," pp. 314 f.; "Hereditary Genius," Galton; and, for a very destructive view, "Introduction to Psychological Theory," Bowne, pp. 49 ff. See also refs. under Weber's law above.

[17] Cf. "Principles of Psychology," Vol. I., Chap. XIII.

degree improbable as well" (p. 547); and (3) that "Weber's law is *probably* purely physical" (p. 548). And he concludes, "the only amusing part of it is that Fechner's critics should always feel bound, after smiting his theories hip and thigh and leaving not a stick of them standing, to wind up by saying that nevertheless to him belongs the *imperishable glory* of first formulating them and thereby turning psychology into an *exact science* (!):

> "And everybody praised the duke
> Who this great fight did win."
> "But what good came of it at last?"
> Quoth little Peterkin.
> "Why, that I can not tell," said he,
> "*But 'twas a famous victory*" (p. 549).

All of which need not be taken with too many grimaces. For it merely means that physiological psychology remains in the "natural history" stage—it is still occupied mainly in the assemblage of facts. And no one would oppose it were it not that some foolish partisans, after the fashion of fools in all ages, go about to magnify their office. That psychology can never hope to be "exact" after the kind of physics, or even, mayhap, physiology, seems beyond doubt. Yet one attaches little, if any, weight to this remark. For, as physiology ceases to be physiology when it assimilates itself to physics or to chemistry, so psychology ceases to be psychology when it attempts to become physiology, just as sociology, masquerading in the guise of psychology, is no science, but simply a homeless bastard. Sceptical as the conclusion may seem, Fechner, nevertheless, needs no justification, as his work for esthetics proves abundantly.[18] For, in psychology, as in every other science, the investigator assumes the intelligibility of nature; and then, by an attack in detail, attempts to show that natural interrelations are as his conceptual conclusions anticipated they would be. And from this process no sphere of experience can be held exempt. Doubtless, the application is most difficult in psychology, because there abstraction from either body or mind leads to positive error. But, here, again, we are only saying that, despite all its laboratories and apparatus, psychology remains that new revelation—a philosophical science. And to my mind its first-rate importance grounds exactly in this very fact.

[18] Cf. "Fechner," Lasswitz, p. 101.

THE NATURE, ORIGIN AND FUNCTION OF HUMOR

By LINUS W. KLINE, Ph.D.

I. Introduction

NO stimulus, perhaps, more mercifully and effectually breaks the surface tension of consciousness, thereby conditioning the mind for a stronger forward movement, than that of humor. It is the one universal dispensary for human kind: a medicine for the poor, a tonic for the rich, a recreation for the fatigued and a beneficent check to the strenuous. It acts as a shield to the reformer, as an entering wedge to the recluse and as a decoy for barter and trade. A German writer observes that it is a parachute to the balloon of life. To change the figure, it is a switch on the highway of life to prevent human collisions. Zenophon reckons that the man who makes an audience laugh has done a lesser service than the one who moves it to tears. But the comedian Philippos, when Socrates asked him of what he was proud, declared, "I believe that I ought to be as proud of my right to the gift of arousing laughter, as Kallipides, the tragedian, of his art in causing tears."[1]

Darwin points out that the causes of laughter are legion and exceedingly complex.[2] Humor may often be a cause, in which case it is the mental aspect of a psychophysical fact. The mental aspect, only, forms the subject matter of this paper. It offers problems for investigation similar to any other concrete mental fact. I propose to show that the character of its stimuli, the conditions of its origin in the race and in the individual, its nature and function as a mental process, are discoverable, describable and susceptible of explanation.[3]

II. The Nature of the Stimulus

(a) *Non-humorous Stimuli*

The immensity of space, the infinitude of time, the motion of the heavenly bodies and all cosmic rhythms are void of humor. The same thing is apparent of all physical, chemical and mathematical laws, and likewise of all macroscopic things of earth such as the waters, the tidal movements, the cataracts, the mountains, the forests, the deserts and

[1] Nick, Fr., "Narrenfeste," Bd. I., Zeit. 2, 1861.

[2] Darwin, Chas., "The Expression of the Emotions in Man and Animals," p. 198.

[3] The physiological conditions of laughter have been treated at length by Ewald Hecker and Herbert Spencer; the latter's contribution still remains the classic on this subject.

the plains. Swift rhythmic movements of organic life in the large, and the orderly expression of life processes, as the heart-beat, the mystery of sleep, birth and death, may inspire awe and dread, but never humor.

There is a large group of objects and actions which incite feelings of contempt, disgust and loathing, such as parasites, creeping and slimy things, filth, skin and eye diseases, all forms of tyranny, treachery, poltroonery, ingratitude and, according to Bain, "the entire catalogue of the vanities given by Solomon."

All common and customary activities and events and objects of familiar notice constitute, so far as the pleasure-pain field is concerned, an indifferent zone.

By this eliminating process it appears that the conditions averse to humor are: (1) The macroscopic things of the world, including her laws, order, harmony and rhythm, (2) those things which are inimical to life and freedom, (3) those things, largely of the social order, that have become habituated, regular in occurrence and necessary to human comfort.

(b) *Humorous Stimuli*

There remain for consideration: (1) Animals and their actions, (2) man, (3) his actions, (4) clothes, (5) customs and manners, (6) words, language and thought.

1. *Animals.*—The statements that "There is no comic outside of what is properly human," and that the lower life and inanimate objects provoke humor only when endowed with human qualities, are perhaps true and the many exceptions simply prove the rule. Small animals, like small people, are more likely to provoke humor than large ones. The bantams and games are the clowns and Don Quixotes of poultrydom, while the Plymouth Rocks and Shanghais are the prosaic members. The poodles, terriers and spaniels are the fun-makers of the kennel; the St. Bernards, great Danes and bulldogs command our serious respect and sometimes more. When an animal of one class does the task common to an animal of quite a different class, it is apt to provoke humor. An ox in shafts drawing a top buggy, mules, asses or buffalos running a race, an elephant drawing a chariot are examples. But if the animal is set to doing a human task the humor is intensified. The inimitable Æsop, endowing animals with human craft and qualities, made this style of humor classical for all time. It appears in modern humor in the stunts of Johnny Bear, in the clever tricks of Brer Rabbit and Brer Fox and in the county fairs, charity balls, political conventions, clinics for appendicitis and the like conducted by divers species humanly socialized.

2. *Man.*—Man may provoke humor by his size, especially if extremes meet. The undersized is likely to amuse—especially in his pre-

tensions and passions. Unusual features, types of ugliness, odd shapes, Falstaff proportions, contain humorous elements.

3. *Actions.*—Mimicry and all actions of a pretentious and useless sort and in false time and space relations may provoke humor. All mimicry is humorous, whether in the form of the puppet show, the pantomime, the burlesque or the comedy. Hazlitt calls attention to a large group of humorous acts as seen in the "pursuit of uncertain pleasure or idle gallantry." Professor James refers to the same subject in describing our desire for recognition: "We are crazy to get a visiting list which shall be large, to be able to say when any one is mentioned, 'Oh! I know him well' . . . there is a whole race of beings to-day whose passion is to keep their names in the newspaper, no matter under what heading; 'arrivals and departures,' gossip, even scandal will suit them if nothing better is to be had." Useless actions of the ideomotor and absent-minded type are the causes of many of the comedies of errors in every-day life. A young lady who had partially disrobed to make a toilet at the noon hour, wound up by "saying her prayers," that being the usual next step in the evening. A college girl stopped at her own room and knocked vigorously for admission. Forgetfulness, too, is often a source of humor. Here belong the host of stories of the forgetful and absent-minded professor, from which we select one. A certain professor asked the lady of his choice for her hand, in total disregard of the fact that he had made the same request with the happiest result on the day preceding. The wrong use of objects, tools and machinery often makes an act humorous; for instance, posting letters in a neighbor's private letter box, an Indian taking his family to church in a hearse purchased for a carriage, sharpening a hand saw by grinding the teeth out of it. Awkwardness is a common type of action naturally humorous. Any action inherently serious may become humorous by occurring out of time or out of place. Singing ahead of time or out of tune, applauding alone, answering questions at the wrong time at a marriage service, an unmindful deacon removing his small coat with his overcoat and sitting down in his shirt sleeves in church, are cases in point. Hazlitt remarks, "In Jocular history everybody is at angles to real life; people do precisely what they ought not to do, say what they ought not to say, are found where they ought not to be found."

4. *Clothes.*—Clowns and professional fools supplement their wit, humor and mimicry by their well-known forms of dress. Johnny Bull, Uncle Sam and Santa Claus are always received good-naturedly partly on account of their dress. Hallowe'en, masked balls, the Mardi Gras and Carnivals ancient and modern owe much of their charming good humor to dress. It is well known that we laugh at the dress of foreigners, and they at ours. "Three chimney sweeps meeting three Chinese in Lincoln's-inn-fields, they laughed at one another till they were ready to drop down. . . . Any one dressed in the height of

fashion or quite out of it is equally an object of ridicule." Doubtless if the centuries could rise up and view each other *en masse,* their first act would be mutual laughter at each other's clothes.

5. *Customs and Manners.*—As stimulants of humor customs and manners have, perhaps, no equal. They excite it alike in the vulgar and the cultured, in the illiterate and the learned. They appear in excesses and exaggerations and in violating time and space relations, either as innovations or as lingering too long. To appear in excess or out of time and place implies some age and stability in human institutions. Norms and standards of fashions must be formed, regularity in activities must freeze into custom and the free spirit of good-fellowship and of social intercourse must become habituated to the plane of manners before the spirit of satire, wit and humor can react for or against them. The gentle old countryman whose habit it had been to exchange the courtesies of life with his fellow travelers along the country highway, awakened a ripple of humor when he graciously shook hands with all the occupants of a city street car. Mark Twain in his "Connecticut Yankee at King Arthur's Court," gives us a charming glimpse of the humor of manners and customs out of time. Fielding observes of even so playful a dramatist as Sheridan that he attacks affectation, false sentiments, hollow forms and empty words in life and literature.

6. *Words, Language and Thought.*—This is the favorite tramping ground for both the humorist and his critic. The most delicate, subtle and refined specimens occur here. It is also here that an attempt to give an adequate treatment resembles trying to bottle a fog or lasso a cloud. To make some headway, however, we are under the necessity of drawing a few distinctions. All words, language and thought, not humorous to the speaker but so interpreted by the observer, may be termed *unconscious humor* (following the lead of common usage). The humorous interpretation of unconscious humor may be called *passive humor.* All deliberate manipulation of words, language and thoughts by the subject for humorous effects may be considered *active humor.* In what follows the text will show which sort is meant.[4] Concerning words, it appears that their misspelling, mispronunciation, misinterpretation, forced usage and misusage, punning, repetition, localisms and foreign accents endow them with a certain degree of humor. Many of the humorous classics use one or more of these methods. The writings of "Artemus Ward" and "Josh Billings" about exhaust the possibilities of misspelling. Negro, Irish and foreign dialects now occupy much of the field of mispronunciation and misinterpretation. Dickens displays the worth of forced usage in the inimitable Pickwick. Sheridan creates Mrs. Malaprop largely by these methods. Shakespeare had the courage to pun to his own satisfaction. Dickens has

[4] For a discussion of the forms of the comic see Th. Lipps, "Komik und Humor," pp. 78–102.

used repetition to a fine effect in several of his characters. We recall Mr. Totts', "of no consequence," and Joey Bagstock who is "devilishly sly." Provincialisms and foreign accents enter into the humor of daily life rather than that of literature.

The unconscious distortion of words by the illiterate, the naïve and the pretentious adds to the quality of this sort of humor. In fact, whether the distortions are "made" or are unconscious, their humor depends on our apprehending them as such. A farmer who made daily business trips to Richmond assured his neighbor that he always dined at a "first-class reservoir." A colored servant in my own home asked for a half holiday in order to go on a "railroad squashin" (excursion). (What irony in the light of recent events!)

Language much more than custom and manners requires a civilization of some age and stability in order to furnish both the conditions and material for humor. George Meredith[5] has urged that it requires a society of cultivated men and women, wherein ideas are current and of some duration and perceptions quick, that the humorist may be furnished with matter and an audience. "The semibarbarism of merely giddy communities and feverish emotional periods" creates no humor.

Quaintness in language as in other things possesses a tinge of humor. A description of the table manners of a nun or a lady of culture in modern language would be sorry business, but when Chaucer says of the nun

> At mete wel y-taught was she with-alle;
> She leet no morsel from hir lippes falle,
> Ne wette hir fingres in hir sauce depe.

He stimulates our sense of humor. Here too belong the grave and serious in connection with trivial and prosaic matters, for example the records of colonial legislative enactments and the minutes of their town meetings. Many of the failures of language to fit the thought yield humor; a common type is verbosity. In this connection I give the following:

MT. STERLING (KY.) REPORTER. (COLORED)

Dear Editor: Please allow me a space in your momentous Gazette to reciprocate my gratitude to the indefatigably workers of the Evergreen Baptist Church. While sitting in my studio last Friday evening greatly absorbed in the monotonous problem so-called Negro problem I were interposed by the anthem, "There shall be showers of blessing" which rendered me surprisal happy. . . . After a general parlance I were divinely impressed to descant on the altronistic spirit that should characterize the christiandom. A sumptuous repast followed and all present shaiated their gastronomic desire. Bro. Ben Mitchell distinguished himself by his implacable vorasity. May God bless the members of the Evergreen Baptist Church. Many thanks. F. B.—*Pastor.*

Opposed to the quaint is the ultra-slang, brusque catch-words and phrases of common life; witness the monologues of "Chimmie Faddin" and the writings of George Ade.

[5] Meredith, George, "An Essay on Comedy," p. 8, London, 1905.

The speech of the excited, the irritated and the fatigued often becomes humorous by inversions. A prospective bridegroom at the church door in consultation with his minister inquires excitedly, "Is it kistomary to cuss the bride?" Grumio answers his master, "Ah, sir, they be ready: the oats have eaten the horses" (see "The Taming of the Shrew," Act III., Scene 2).

What a man thinks and feels, although serious to him, may be just as much an object of humor as a situation, an awkward movement or a form of speech. The unconscious maker of humor in thought is your next neighbor. Every one is a contributor on occasions to this type. Certain classes, however, are much more productive than others; among them may be mentioned the ignorant, the illiterate, the inexperienced, the credulous, the skeptic, the superstitious, the over-serious, the vain and the prosaic. Their humor appears in their attempt to deal with situations and problems somewhat beyond their ken. The ignorant and illiterate amuse by their literalisms, pretensions, evasions and superstitions. In looking over some papers written by students of Plato's Republic I noticed that they usually began the story of the Lydian shepherd, Gyges, and his magic ring, in somewhat this fashion: "A shepherd lad was tending his flock on a mountain side when suddenly a violent storm arose. The rain fell in torrents, the ground was rent asunder by an earthquake and a yawning gulf opened in the very midst of the flock. Inspired by curiosity, he descended into the gulf and among the marvelous objects he saw a hollow brazen horse," etc. One paper ran thuswise: "A shepherd one day noticed a large horse standing in a hole in the ground. He climbed inside," etc. Dickens employs pretensions in the interests of humor, as Joe Gargery's deceptive attempts at reading for Pip's benefit. Thackeray's Capt. Rawdon Crawley is a fine specimen of stupid ignorance. I am persuaded that many superstitions are kept alive by their humorous vein. To turn back is bad luck, the "spell" may be broken by making a cross in the path with the big toe and then spitting in it. A negro boy taught us this when children. We did not believe it, but practised it for fun. Inexperience is the lot of childhood, and the condition of its humor, which is expressed in the questions, in the wonderings and in the explanations of child thought. This is abundantly verified in the writings of the "pot-hunters" of childlore. The humor of the credulous appears in a condensed form in their responses to the yarn-spinner and the prank-player. The faith and works of the inventor are often ahead of his time and are therefore sometimes the butt of the common mind. Cervantes made Don Quixote the humorous peer of all time among the over-serious, and Malvolio of Twelfth Night typifies the humor of vanity among individuals of small parts. Putting great force into small matters, exercising much thought over petty questions, exalting trifles into the plane of the magnificent form perennial sources of humor.

Active Thought Humor.—This type of thought humor is as complex and infinite in variety as thought itself. Cicero was the first to have extensively considered it, and even he apologized for his number of headings. He says, "I have divided these matters into too many headings already." He includes: deceiving expectation, satirizing the tempers of others, playing humorously upon our own, comparing a thing with something worse (Bain's degradation theory), dissembling, uttering apparent absurdities, pretended misunderstandings, wishing the impossible, uniting discordant particulars (Krapelin's theory of the comic), concealed suspicion of ridicule. He illustrates the latter by "the Sicilian who, when a friend of his made lamentations to him, saying that his wife had hanged herself upon a fig tree, said, I beseech you give me some shoots of that tree, that I may plant them."

Cicero's[6] list has been considerably increased by later writers without contributing anything essentially new. I shall not attempt to increase the list. I wish here to emphasize some of the more common ways by which active thought uses the material, already detailed, in the interest of humor. Some of the simpler uses are seen in childhood in their "fooling" and playful deception. The vigorous use that the child makes of "April fool" is an example. The child employs the recognition process for humorous effects in his mimicry, drawings and riddles. To draw an object with doubtful resemblance and require an adult to identify it affords him pleasure. Constructive imagination is put to the service of humor by the various forms of roguery. A negro boy asked my brother of twelve if he had seen a stray cow. "Did she wear a small bell?" asked my brother. "Yeah, dat's de cow." "Did she have a short tail?" "Yeah, dat's de veay cow." "Then I haven't seen her." The essential principle in cartooning is to display an association formed either by evident or obscure resemblances. Both wit and humor of the highest type depend upon the power of perceiving unusual, exaggerated and remote relationships. Mark Twain stands alone in this country in the use of exaggerated relationships. Groos[7] has marshaled considerable evidence to show that the higher mental processes may be used in the service of play. Kant pointed out that play and humor are closely related, if not actually crossing each other. This suggests the notion that every process exerted in the service of play may at the same time, or under slightly different conditions, be used for purposes of humor. The making and solving of conundrums and riddles, impromptu and otherwise, are practised no less for their humor than for their play value. I hardly need mention the coarse type of active thought humor which makes a liberal use of profanity and other vulgarisms.

[6] Cicero, "Oratory and Orators," p. 304, Bohn's edition.

[7] Groos, Karl, "The Play of Man," pp. 152–158.

III. The Nature and Origin of Humor as a Mental Process

Schuetze, in 1817, and Hazlitt, in 1819, summarized the various opinions as to the nature of humor up to their time. The former cites some fifteen different authorities and views. Schopenhauer, in 1819, made a decided contribution in that he attempted an exact description of the mental processes involved. Since then the nature of the mental process and its physiological basis have been the main points of discussion. Schuetze, Hoeffding and Sully call attention to the sense of freedom involved. Penjon, in 1893, described at some length the relation of this sense to humor.

I have already pointed out that the appreciation of law, of order, of harmony and of those things that are inimical to life and freedom begets a sober mental attitude, the intensity of which varies with the weightiness of the matter and the issues involved. Now if, when dealing with such matters, the thinking process continues organized and controlled and progresses towards an end, it is termed rational. But if the mental tension exceeds the capacity for controlled thinking, brought on by the sudden triumph of wrong and evil values, disruption of the thinking process at once ensues, accompanied by an unpleasant emotion ranging from mild disappointment to the tragic; if, on the contrary, the disruption is caused by the sudden triumph of good values, a pleasant emotion results. In either case organized and rational processes give way to those of an uncontrolled and emotional sort. The mental stream has had its banks torn away and its forward movement stopped, voluntary movements are replaced by hereditary. In the more intense forms a reversion to primitive conditions may occur; for we then do and say things that may shame us in our sober moments. Now the humor process occurs in just such a disrupted consciousness induced by the triumph of good and pleasurable values preceded by a mental tension similar, but not always equal, to that preceding emotions. The common and quiet forms of humor usually occur in a consciousness that has been running at its usual strength and depth, sufficiently organized to command the situation, assume a definite form and take on a certain strength of surface tension. (The term surface tension simply extends the water metaphors of psychology in a logical direction. I use it to indicate the impervious condition of consciousness formed in any attentive state, the strength of the surface tension being in direct proportion to the intensity of attention.) The function of the humor stimulus consists in cutting the surface tension, in taking the hide off of consciousness as it were, and in breaking up in part only its organization, which is at once followed by the humor feeling—the next link in the conscious chain. The principal elements in the humor process consist (1) of the perception of the stimulus, (2) the sense of freedom, (3) its recognition. These elements are each suffused by a pleasurable tone and produce by their total synthesis the unique humor tone. The uniqueness of the tone is the crux of the matter. The mental tension preceding the humor process, although an essential condition thereto, is not a differentium, for it precedes any and all emotional states.

The clue lies in the nature of the humor stimulus, and the relation sustained to it by the individual. This is in line with Dr. Dewey's theory of the differentia among the several emotions themselves. He holds that each emotion is marked off from other emotions by the different reactions produced by the exciting fact. I have indicated that the humor stimulus belongs to an order of knowledge whose laws, uniformities, manners and customs have arisen since the human mind has attained its present estate. Contrast with the humorous stimuli the non-humorous, and it appears, humanly speaking, that the latter has always existed. The heavens, the laws of matter, cosmic forces of whatever sort, were in full swing when human consciousness dawned, their operation has participated in mind evolution and to that extent has impressed law and order upon it. Therefore, when we are engaged with these things, sober thinking, pleasant or unpleasant emotions, are the outcome, but never humor. But it will be noticed that the humorous stimuli consist of departures, of exaggerations, even of violations of the laws, uniformities, concepts and what not that have evolved out of man's experience. The significant fact for humor is that these departures, and exaggerations do not disturb the recognized values of good and evil. The mind maintains all the while a disinterested attitude toward the object of its activity. We seek neither to correct nor further to exaggerate the departure from the normal. It is time to feel and not to act. We enter into æsthetic rather than practical relations with the object of our humor; should we seek the practical, humor at once ceases, issuing perhaps, in bitterness or joy, sarcasm or flattery, indignation or admiration.[8] Penjon,[9] writing upon this point, says:

> I shall have to distinguish these varieties of the comic laugh, sometimes so near to tears and often so cruel. But if one separates, as must be done, the causes which too easily deform the comic and make of it an emotion of wickedness or bitterness, the comic emotion will appear purely disinterested. I mean by this that the object or the event which is the occasion of the comic excludes every idea of loss or of profit, that it makes us conceive neither hope nor fear and seems to us at the same time neither advantageous nor harmful to any one; it is worth in itself what it is worth without adding to our idea of it any consideration of end or ideal. The comic emotion is then essentially a play emotion.

The humor process then, like play, is its own end and justification. The kinship between humor and play already indicated not only sug-

[8] For subjective proof of this one may read Benjamin Franklin's "Polly Baker's Defense"; also Dickens's satire on American life in "Martin Chuzzlewit."

[9] Penjon, A., "Le Rire et la Liberté," *Revue Philosophique*, pp. 113–140, August, 1893.

gests relationships between humor and freedom, which Penjon has so well worked out, and between humor and æsthetics, long ago indicated by Kant and recently by Lipps, but that mental activity so long interpreted as play should be credited to humor. I have already indicated the survival value of humor for superstitions. It doubtless performs a similar and larger function for play. Humor, then, is an end in itself. It is disinterested in its object. This fact constitutes it first differentium.

I have already indicated that the sense of freedom is a constituent element in the humor process. Its consideration is next in order. To that end I submit some of the evidence as it had formed in my own mind before meeting with Penjon's more extended account. The family and guests are seated about the fireside enjoying the moments of silence. The only light is that of the glowing embers. A smouldering bit of bark suddenly flashes up and a smile plays over the faces of the silent group. The stroke of a sweet-toned clock, or a sneeze, or the dropping and rolling of a sewing thimble or a ball of yarn produces under similar conditions the same effect. A group of boys are seated on the bank of a bathing pond apparently gazing at the water's glassy surface. Suddenly it is broken by a few drops of rain out of a cloudless sky. The boys smile. The humor in such cases is weak and simple. At such times consciousness is damped down to dreamy monotonous processes under lax attention, and the mild humor results from the sudden, delicate and harmless stimulus piercing its surface tension, disrupting its feeble structure, and permitting it to flow in a more free and spontaneous fashion. This simple type finds verification writ large in every-day life. Objects and actions of little or no inherent humor may become excruciatingly humorous under hard and tense conditions. "Snickerin' at nothin'" in the schoolroom, giggling before strangers and company, especially when at the table, the increasing intensity of the annoying return waves of humor on solemn occasions, are cases in point. Members of college glee clubs inform me that they see humor in everything while on their vacation musical tours. Darwin records that the German soldiers before the siege of Paris, after strong excitement from exposure to extreme danger, were particularly apt to burst into laughter at the smallest joke. I have received abundant reliable evidence that the sufferers of the San Francisco earthquake, while enduring intense mental strain, burst into laughter on the slightest provocation. This and like cases should not be confounded with hysteria, which may occur unaccompanied by mental strain. The history of humorous literature discloses the fact that it is most prolific in those crises and changes in human affairs at which the consciousness of freedom breaks out. The work of the cartoonist is most vigorous and poignant when official tyranny and high-handed abuses are laying heavy hands on the public. We recall the heroic work of Th. Nast[10] during the brazen days of the Tweed Ring. Martin[11] observes that the parody was first introduced during the performance of Greek tragedies to relieve the audience from the intense mental strain. In the severe atmosphere of the king's court the court fool was an important adjunct. In reality his was the freest personality of the group, the king not excepted. A most striking example of this in literature is that of King Lear and his fool.

These considerations indicate an intimate kinship between the humor process and the sense of freedom. The real relation becomes apparent when the nature of the stimulus is taken into account. It has already been shown that the humor stimulus violates and breaks up the order and mechanism about us. It appears as the only objective fact in our experience that dares to defy the social order with impunity, that can violate ruthlessly, without pain and without apology, the human contrivances about us, and thereby not only remind us that freedom is an abiding reality, but that we may escape, temporarily at least, from the uniformities and mechanisms of life. We are rather chary of an over-scientific game, one in which luck and spontaneity are entirely supplanted by principles and rigid regulations. Speaking of a game or a contest as a "dead sure thing" is an implication that spontaneity and life are inoperative. Any instrument, therefore, that reveals freedom to us through the veil of mechanism and the social order will produce pleasure. Play, art and the humor stimulus are such instruments; play is largely for the young, art for the trained and educated, but the humor stimulus is for every one. The second differentium of the humor process, therefore, is the sense of freedom.

The failure to see that the sense of freedom is a constituent part of humor is doubtless responsible for the "superiority" (and its opposite statement "degradation") theory. The sense of power is pleasurable, but not humorous, for the reasons that (1) the sense of power contains an element of *practical* relationship and (2) the humor stimulus *does not* make us aware of power. Incongruity, descending or otherwise, all disorders of time and space relations in our actions, customs and language, deceived expectation, all disorders of mechanized living movements are only humorous when they excite the sense of freedom. Incongruities are not inherently humorous. They may become excitants of humor by revealing freedom behind human uniformities. It would appear then that the multiplicity of humor theories may be resolved into the freedom theory. The theories hitherto advanced have been more a classification of humorous stimuli than an explanation of humor as a mental process.

A cross section of our adult mental life shows three interrelated aspects: (1) an aspect composed of hereditary factors (unlearned reactions), (2) a well-defined aspect of acquired factors or mechanisms

[10] "Nast, Th., His Period and His Pictures," The Macmillan Company, 1904.

[11] Martin, A. S., "Parody," p. 1.

(learned reactions), composed of what the individual does for himself and what is done for him, and (3) an ill-defined aspect that permeates the other two and in addition occupies a separate existence of its own made up of unmechanized and elementary mental factors. The second aspect will be recognized as intelligence. Professor Royce[12] calls it "docility." It might be termed mechanized mind in that it represents mind reduced to law and habit. Getting on in the world is dependent to a degree on a certain quantum of mechanized mind. Common speech employs such terms as habit, adjustment, education to designate such an equipment. Several processes are involved in its making, such as imitation, learning by "trial and error," by tradition and by "understanding." Of these ways, those that make the most of voluntary attention are the quickest in results and the most extravagant with mental energy; here it is that mental tension reaches its highest pitch. Relief comes in a variety of well-known ways, humor perhaps being the most unique of the lot, from the fact that it accomplishes its purpose with the least expenditure of mental energy and at a time, too, when the individual can ill afford to make sacrifices in the interest of recreation. Considering then the nature of humor as a mental process, and the nature of its stimulus, together with the conditions under which it appears, it seems highly probable that it emerged as a distinctive process from states of inattentive-freedom immediately preceded by states of necessary-attention.

IV. The Functions of Humor

The psychical function of humor is to delicately cut the surface tension of consciousness and disarrange its structure to the end that it may begin again from a new and strengthened base. It permits our mental forces to reform under cover, as it were, while the battle is still on. Then, too, it clarifies the field and reveals the strategic points, or, to change the figure, it pulls off the mask and exposes the real man. In fact, humor is an instrument to aid in the approach to the realities of life—not metaphysical, but *real*, realities!

The physiological function is common knowledge. Its influence on adipose tissue has passed into a proverb, and Kant cherished the belief that laughter had a beneficent effect upon our entire vegetative life. Hecker advocated that it relieved the anæmia of the brain induced by the tickle.

Its biological function in my judgment is far more unique in mental economy than its nature as a process. I have already referred to the unmechanized aspect of mind, a matter more readily believed than easily proved. To adduce adequate evidence of its existence and of the extent of its magnitude and importance over the mechanized and hereditary portions of mind would lead us too far afield. For a better

[12] Royce, Josiah, "Outlines of Psychology," p. 38.

appreciation of the problem, however, a few considerations on the point seem worth while. First, we register our belief in its existence by such expressions as "mind growth," naïvété, self-activity, spontaneity, genius, "mental initiative," and by more remote terms like open mind, youthful mind, unprejudiced mind, simple mind. Second, many students of mind tacitly accept it and forthwith attempt its description. This is done by Professor Royce in his "Outlines of Psychology." Professor Shaler expresses his conviction of its existence as follows:

> One of the results of the marvelously swift, absolutely free development of man's spirit is that there has as yet been insufficient time for it to become organized as are the conditions of the body. Working in the instinctive manner in which the lower species do their complicated work through the fore-determined mental processes we term instincts, there are always gauges and standards for the endeavors in the mind as there are in the bodily frame. With us, however, all kinds of thinking are still a hurly burly, a confusion, to which time and culture may possibly bring something like the order it has in the lower life, but which probably is ever to remain in its present uncontrolled shape.[13]

Third, biologists are generally agreed that the human hand, the vocal organs and the cerebral cortex have developed possibilities far beyond present realization. Their possibilities are as yet unknown. The capacity of the cortex appears to be infinite with only a small portion reduced to law and order. If we can so confidently assert unlimited capacity of these physical structures, then any lesser conception of mind is, indeed, an untenable one. It does not yet appear what we shall be, but there is a general agreement that the immediate path of evolution will be spiritual rather than physical. And if spiritual, it can only go on in the free portion of mind, in those parts not yet harnessed to matter and frozen into laws and habits. Of course there is universal agreement that the mind should be mechanized to the extent of the needs of common life, of routine business, of the alphabets of learning and of the elements of culture, but anything beyond these points is inimical not only to individual development, but to racial evolution. While, on the other hand, influences that tend to check mechanization and to incline the mind to grapple with the ideal, the novel, the realities rather than the formalities of life prolong the possibilities of spiritual development. Humor and play are two such influences, with the honors in favor of humor. It stands guard at the dividing line between free and mechanized mind, and like play, it keeps the individual young, projects the best of youth into adult life, sets metes and bounds to "docility" and prevents the mental life of the race from hardening into instinctive and hereditary forms of action. It saves to the world its geniuses and saves the individual from the blighting influence of commercial and utilitarian ideals.

[13] Shaler, N. S., "The Measure of Greatness," *Atlantic Monthly*, December, 1906, p. 751.

A BACTERIOLOGICAL STUDY OF SOILED PAPER MONEY

By WARREN W. HILDITCH

THE SHEFFIELD LABORATORY OF BACTERIOLOGY AND HYGIENE, YALE UNIVERSITY

IT is generally acknowledged to-day that little progress can be made in sanitation or hygiene without the general cooperation of the public. To obtain this cooperation, it is essential that the people be correctly informed upon all sanitary or hygienic subjects; for should it be found that the demands for this or that improvement are not based upon true scientific facts, how can success be hoped for, when a really essential reform is brought forth?

All will agree that soiled paper money is at least not a thing of beauty, and the unpleasant odors and filth accompanying some bills offend every esthetic sense, and give good foundation for the demand for a more frequent issue or redemption of our currency by the government. Everybody who has traveled abroad will admit that our paper currency is a disgrace when compared to the clean, crisp money to be found in many of the foreign countries, where soiled or worn bills are almost unknown.

In our arguments for clean money, should we include the one which claims that soiled paper money is a frequent medium for the transmission of infectious diseases? The popular opinion to-day is that paper money is very filthy and extremely dangerous to handle, as on it may be found any and all kinds of disease germs known to science. Many people, especially women, have a dread and horror of dirty money and often insist on clean bills when getting change; yet cashiers and bank tellers very seldom think of the filth on the money, and they have no aversion for it. Physicians often seem eager to blame our currency for the spread of disease or the cause of death, especially when it is difficult to find out the true source of infection.

The frequent occurrence of diphtheria and tuberculosis led me to be especially interested in attempts to find *Bacillus diphtheriæ* and the tubercle bacillus on money, and thus prove it to be one medium for the transmission of these diseases. The soiled money used for this study was the dirtiest I could obtain from various sources, such as railroad, trolley and theatre ticket offices, banks, drug stores and individuals in different parts of the state. Some of the bills were much more worn than others, being very soft, cracked and soiled, with frayed edges.

Each bill was thoroughly brushed in twenty-five cubic centimeters of sterile physiological salt solution, the work being carried on under a glass jar to avoid contamination from the air. In order to estimate the number of bacteria present, 0.5 c.c. of this wash water were diluted with 10 c.c. of physiological salt solution and three series of agar plates were poured, using 0.2, 0.3 and 0.5 c.c. of this dilution. The wash fluid was then measured and centrifugated, the coarse particles of dirt and paper thus thrown down were filtered off and the fluid again centrifugated. With the sediment of bacteria and fine dirt obtained in this manner, I inoculated three bouillon tubes in order to look for streptococci and other forms that might develop. Ten tubes of serum were smeared for the detection of *Bacillus diphtheriæ*, while the rest of the sediment was then carefully injected subcutaneously into a guinea pig. The animals were closely observed for several days so that in case of a fatality an autopsy could be performed immediately after death and the lesions thus more correctly observed. All media used for this experiment were prepared according to the standard method of the American Public Health Association, with a final reaction of + 0.8 (0.8 per cent. acid).

At first I intended to make a study of only twelve bills, since it required a full week to complete the study of each bill; but the appearance in the daily press of accounts of the present agitation for clean money led me to make a total of twenty-four examinations. In twenty of these all the sediment was injected into guinea pigs, in order to allow the development of tuberculosis or septicæmias that might be caused by the bacteria in the sediment; in the other four, the sediment was used for smearing serum plates to detect *Bacillus diphtheriæ*.

It was surprising to find the flora so constant, *Staphylococcus pyogenes albus* being by far the most common form present, with various members of the subtilis group next; *Staphylococcus pyogenes aureus* was found on all bills, but not in large numbers. The following were found on some bills, but always few in number; *Staphylococcus cereus albus*, a streptothrix, *Sarcina lutea*, streptococci and in one instance, *Bacillus xerosis*. Other chromogenic bacteria were frequently found but not identified.

The numbers of bacteria present on the bills ranged from 14,000 up to 586,000, with an average for twenty-one bills of 142,000. There seemed to be no connection between the amount of dirt and the number of bacteria present; the cleanest-looking bill that I used had next to the highest count (405,000), while the bill that looked the dirtiest had but 38,000. When a bill has been in circulation for a short time and has become somewhat cracked, and its peculiar glaze worn off, the bacteria very easily cling to it without the presence of dirt and grease.

All inoculations gave negative results, the time limit being placed at from six to seven weeks. All of the guinea pigs showed more or less local reaction, with swelling of the lymph glands of the groin, but none gave any indication of even temporary illness. Inoculations of pure cultures of staphylococci, as well as of *Bacillus xerosis* (which was at first suspected of being *Bacillus diphtheriæ*) also gave negative results.

From the observations that I have made, it would seem that the bacteria present on paper money are non-virulent and the forms most common are the air forms. Could the loss of virulence be due to drying, the bills having a peculiar dry feeling, no matter how moist the air; or is there some antiseptic action in the ink used for the printing of the bills? I have not taken up the question as to why the bacteria found on money are without virulence, but have confined this study to a careful search for pathogenic forms that might be present on the bills.

The literature on this subject is exceedingly scanty. I have been unable to find any report upon any good scientific work done along this line. Inquiry at the Congressional Library at Washington revealed only four articles—one in Spanish, one in German and two in English, while inquiry among a number of scientific men failed to give me any further assistance with the literature upon the subject of the transmission of infectious diseases through paper money.

That the interest in dirty money, or desire for clean money, is not of recent origin is shown in an article by Dr. Otto Müller,[1] which appeared in 1879. He suggests that money is one means of transmitting the infectious diseases, and although it is extremely difficult to prove an actual case, it certainly offers possibilities. He lays particular emphasis upon the pernicious habit of giving coins to children to play with, especially when they are sick; and also the habit of keeping money under bed pillows, or in commodes or closets where linen or food is kept.

Drs. Acosta and Rossi[2] reported in a Havana journal the results of bacteriological examinations of bank notes made by them. They examined two bills that had been in circulation for some time and found them loaded with germs of various kinds and degrees of malignancy. Cultures were made from the scrapings of the notes and these were injected into the peritoneal cavity of rats and guinea-pigs, most of which died within twenty-four hours, the post-mortem examinations showing signs of peritonitis and congestion of the liver and kidneys. They did not identify any of those germs having "various degrees of malignancy." The fact that the animals died within twenty-four hours indicates that death was not due to the action of any one or more pathogenic forms that might have been present, but rather to the great numbers of bacteria suddenly thrown into the peritoneal cavity.

[1] "Das Geld, ein Krankheitsvermittler," *Monatsblatt f. Offentliche Gesundheitspflege*, 1879, No. 2, p. 173.

[2] *Medical Record*, August 27, 1892.

Fifteen years ago Dr. J. C. Graham,[3] of Columbus, Ohio, carried on a study of soiled paper money, to furnish data to be used as the basis of a bill placed before Congress for a more frequent redemption of damaged paper currency. He examined fourteen bills, simply shaking them in 50 c.c. of distilled water and adding portions (0.1 c.c.) of this wash fluid to gelatin, for plating.

Agar was used twice, with resulting growth only once; but the author presumes that not all microbes present developed, since many pathogenic forms, especially *Bacillus diphtheriæ* and the tubercle bacillus, will not grow at a temperature much below that of the body, or on the media used. He was able to recognize only *Bacillus subtilis.* To determine the pathogenic characteristics, only two inoculations were made; a twenty-four hour bouillon culture of an unknown bacillus was injected subcutaneously, into a full-grown rabbit, with negative results, excepting a slight rise of temperature. For the second inoculation, the wash fluid from a bill was placed in the incubator for forty-eight hours, and fifteen minims of this were injected into the peritoneal cavity of a rabbit, with negative results. He usually found only two or three species, but in one case claimed to have found five; three bacilli, one of them a spore form, an ordinary micrococcus and a diplococcus. One bill he estimated to have the enormous number of 901,320,000 bacteria upon it. He sums up his article by saying that "Money may be a source of danger by transmitting diseases."

Personally, I can not see that the object of Graham's study was accomplished, for no data were given which could support a bill for a more frequent redemption of our paper currency. The author himself saw the faults of his experiments when he presumed that not all bacteria present developed, especially since the ones in which he was most interested, the pathogenic forms, particularly, *Bacillus diphtheriæ* and the tubercle bacillus, would not grow at a temperature much below that of the body or on the media used: yet he did not attempt to overcome these faults.

In *Revista Medica de Bogota* of July, 1904,[4] there is an article on "The Spread of Infectious Diseases by Paper Money." The author (his name was not given) suggests that the rapid increase of leprosy, in a certain locality during the past three years, may be due to the money in circulation, and he suggests a special currency for lepers. A bacteriological study was made by macerating some bills (twenty) in sterile, distilled water and allowing the wash to stand two or three days in a cylinder. The sediment was pipetted off and smears of it examined. The only germ identified was *Bacillus subtilis,* though

[3] "A Bacteriological Study of Soiled Paper Money," Columbus (O.) *Medical Journal*, Vol. XI., 1892–93, p. 391.

[4] "Del Contagio par el papel moneda," *Revista Medica de Bogota*, Julis, 1904, No. 291, p. 355.

three or four other species were observed. No animal inoculations were made.

Writing on "Money as a Carrier of Infection,"[5] in 1895, C. I. Wendt says: "A thoughtful man and careful student will want some positive information on this subject." He reports upon the experiments of Professor Bolton, on coins, showing that when a coin is placed in the center of a sterile Petri dish, and agar which has been inoculated with pathogenic organisms is poured over it, the medium immediately surrounding the coin reveals no growth, but remains sterile, due to the slight solution of copper, as shown by the potassium ferrocyanide reaction. These experiments should prove of some interest and value by setting at rest any fears which might have been entertained as to the power of coins to act as carriers of disease germs, and by reason of grease and dirt on them, to allow of bacterial growth.

Thus we see that this subject has received no truly scientific study, and those investigations that have been made show little or no merit. Of the various forms of bacteria found upon the dirty bills only *Bacillus subtilis* was identified, and no trace of any pathogenic forms could be found, through either cultures or animal experiments. Inoculations were made in only a few cases, and these all proved negative. In the study upon coins no attempt was made to find what forms of bacteria are common on them, and the results given above do not show coins to be incapable of carrying disease germs, but merely indicate that coins placed in certain media yield enough copper for solution to prevent the growth of bacteria. Coins, as we handle them, do not usually have moisture upon them, and the dry alloy has no antiseptic action; so we should expect to find some bacteria upon coins, as on the bills.

My attention was first called to the present agitation for clean money by articles appearing in the New Haven *Register* and other papers, some weeks after the beginning of this study. Reference was made to "Clean Money Morrison," whom I found on inquiry to be A. Cressy Morrison, of New York, and the origin of all the articles in the daily press and magazines of the country, to be his pamphlet "Clean Money—Can We Have It? If Not, Why?" Inquiring of Mr. Morrison for reference to any work that he might have done along this line, I was referred to an enclosed copy of his pamphlet and circular letter. This pamphlet was "offered to a carefully selected list of 1,000 of the leading newspapers and magazines of the country, . . . and, with a view to the great value of simultaneous publication, a date of release was placed upon the article, . . . it being presented for editorial comment, judgment and criticism, with the hope that all or part of it be printed."

[5] Hahnemannian Institute, Philadelphia, Vol. II., No. 4, p. 4, February, 1895.

Further quotation from this circular letter aptly describes this recent agitation: "There has been much talk on the subject, but no 'do,'" for Mr. Morrison gives no experimental evidence as a basis for this agitation, but says "the statistics regarding germs and microbes found on coins and bills are from one of the most eminent chemists of New York," who, at the instance of Mr. Morrison, made an especial investigation and found that money is one of the most effective ways by which contagious diseases are disseminated, especially loathsome diseases and "the white man's plague."

The statistics, as given, are from the Research Laboratory of the Board of Health of New York; pennies averaged 26 living bacteria each; dimes, 40; moderately clean bills, 2,250, and dirty bills, 73,000 living bacteria each. In order to have these statistics at first hand, I wrote to Dr. Park, of the Research Laboratory, who informed me that the only study made upon bacteria on money, in his laboratory, was completed some years ago. He also said: "We found paper money to be similar to other paper and rags and capable of carrying living tubercle and diphtheria bacilli for some days or longer. We have never found any evidence whatever of the actual transfer of disease through money."

Mr. Morrison outlines clearly his plan for clean sanitary bills and coins: (1) a much larger issue by the government of bills of small denominations, so that there shall be plenty of new money to redeem the old; (2) free registry of all bills sent to the treasurer of the United States for redemption; (3) the establishment in all states of central government stations to which money may be sent by all banks to be cleansed and polished; (4) the antiseptic cleansing by all banks, stores and corporations. of all coins and bills passing through them; and last, that every individual cleanse and disinfect all money which he receives.

I certainly agree with Mr. Morrison that the government should issue enough new bills of small denominations to replace the old, and that it would be a good plan to allow the people to cooperate in the redeeming of the old bills by making the registry of all bills sent to the treasurer for redemption, free. As for the establishment in all states of government stations for cleansing money, would the expense involved be justified, when we consider that not a single case is on record where an infectious disease has been transmitted through soiled money? Is there any method known whereby we can sterilize a stack of tightly bound bills; or will each bill be sterilized separately, perhaps by being spread on a continuous belt passing through a disinfecting solution? And would not the process of sterilization greatly diminish the (non-bacterial) "life" of a bill?

When one bank official of New Haven was informed about the suggestion that banks, stores and corporations should sterilize all money that passed through them, he asked, "What good would it accomplish to sterilize the same bill two or three times a week? It is surprising how frequently a bill returns to the bank. It is given to one depositor, who uses it for change; soon another depositor obtains it through trade, and when the next deposit is made the bill may again find itself within the same bank."

With a more frequent redemption of soiled money, all these suggestions for such cleanliness and the formation of clean money-clubs may be avoided, and particularly if we learn to keep our fingers away from our mouths both while and after counting money.

Very few people realize the expense and work involved in the redemption of soiled money. Many banks to-day go to great expense and trouble in redeeming soiled and worn bills in order to have crisp, new ones on hand when the demand is made for them. Bankers and business men do not prefer these crisp, new bills, for they can not be counted with as much speed and accuracy as those that have been in circulation for some time. Some banks deposit all their soiled and worn bills with another bank, and thus avoid the expense involved in redeeming them.

All money for redemption must be sorted, so that all bills of one denomination are together; and each denomination must have the various species sorted, such as gold and silver certificates, United States and "coin" notes, etc., while national bank notes must be kept separately. Each package must be labeled with its face value and the words "currency for redemption." National banks pay the express charges on their notes one way, while on all other currency the sender pays the charges both ways. The expense involved is not merely the time taken for sorting the bills or the express rate of forty cents per $1,000, but also the loss of interest and use of the bills while in transit.

During the past six months a series of diseases and deaths have been recorded as being caused by the handling of filthy money. The stimulus for such an increase in the reports of these diseases can easily be traced to abstracts of Morrison's pamphlet appearing in the newspapers and magazines. In the New York *Evening World*, November 8, 1907, there was a report of the death of Edward H. Hall, from "myxœdema," caused by moistening his thumbs on his lips when counting money. Since myxœdema is not considered an infectious disease, this case has no value. The Bridgeport *Standard* was quoted in a local paper on February 25, 1908, concerning the death of John M. Hopkirk, manager of the Mills Hotel No. 2, in New York, who died from scarlatina, contracted, his physicians believe, through the handling of the dirty bills coming from the slums of the city. Personal contact with these poor people who have little or no medical attention and among whom disease often appears in mild and unrecognized forms, seems to have been overlooked as the most probable means of transmission in this case.

"Germs on Money, Harmless—Dr. Doty rejects a popular theory as to source of infection" says the New York *Times* of February 23, 1908. Dr. A. H. Doty is the health officer of the port, New York. I inquired of him whether he had been correctly quoted in that article and he replied that it practically expressed his views; in fact, he gave me a detailed account of his views which were given in his original article appearing in the New York *Tribune* on November 11, 1907, under the headlines, "No Disease on Money—Foolish to Consider It as a Medium of Transmission." Dr. Doty writes: "This heading may be a little misleading as I do not say that it is impossible for money to act as a medium of infection, but that if it does occur, it is only in rare instances, and this question must be settled principally by practical experience."

The United States treasurer, who has given this subject long and careful consideration, is emphatic in his statement that there is not the slightest evidence to show that the employees in his department contract infectious diseases any oftener than others who are not in this line of work. This also applies to bank tellers and clerks. Peculiarly enough, those who claim that they have made a careful study of this question do not seem to understand that persons whose vocation involves the constant handling of money are susceptible to the same outside influences or exposure that others are, and are therefore equally liable to contract infectious diseases in the ordinary way, and that the handling of money does not render them immune to disease.

Dr. Park's statement that he found "paper money to be similar to other paper and rags, and capable of carrying living tubercle and diphtheria bacilli for some days or longer," does not mean that money is a frequent medium for the transmission of infectious diseases.

Dr. Doty has for years made a study of infectious diseases, and especially the medium of their transmission. He has collected reliable statistics from paper manufacturers in this country, and has made a personal investigation of the rag depots of Alexandria, Egypt; yet no evidence has ever been found to show that these rag pickers are more subject to infectious diseases than those not connected with the work. "It is fortunate," he says, "that money constitutes such an unimportant factor in the transmission of disease, as nothing could be more farcical, from a sanitary point of view, than an attempt to disinfect it, although this has been seriously proposed. It is important that those who have given this subject careful investigation should aid in the education of the public, in order that they may have a proper understanding of the matter and not be alarmed by sensational literature on the subject."

I do not claim that my study of twenty-four bills proves conclusively that money is not a means for the transmission of infectious diseases, but I do think that the absence of virulent disease germs shows that soiled money is at least not a common means of transmission of disease. In order to obtain any conclusive evidence on this point it would be necessary to make a careful study of hundreds or even a thousand bills from hospitals and private sick rooms, drug stores and various other sources.

Emphasis must be given to the animal inoculations carried out in connection with this study, for in a study of this kind they are much more important than the culture experiments, when we consider the susceptibility of guinea pigs to many of the infectious diseases, especially tuberculosis and diphtheria. There may develop within the animal body other forms which would not be detected in a study of the cultures or smears.

It is no surprise that the theoretical does not agree with the practical side of the subject under discussion. This is often the case, especially when the subject is one which concerns the general public, the majority of whom readily agrees with any one who says that dirty money is a certain means of transmission of infectious diseases. Why shouldn't this be so, when we think of the dirt and odors that accompany some of our paper currency? The bills have been in contact with many hands, not necessarily infected ones, but some that have at least been in contact with sores or sputum. Certainly a black picture could be painted and the possibilities made to appear enormous; yet another view is clearly set forth by a bank teller who said: "If one stops to think, money can't be a very common means of transmission, for if it were there wouldn't be so many of us alive to-day; the escape from sure death of those whose duty calls for the constant handling of money, is certainly not merely due to chance."

One conclusion that may be drawn, after a careful study of the subject, is that "money constitutes an unimportant factor in the transmission of disease." We want and certainly need a more frequent redemption of our soiled and worn bills, yet the facts and evidences at hand do not justify us in alarming the public needlessly by rash statements concerning our currency. Admitting the possibility that money may act as a medium of transmission, certainly the failure of any virulent disease germs to manifest themselves in the foregoing experiments will allow us to feel a bit easier in regard to dirty money.

FACTS CONCERNING MILK

By A. E. P. ROCKWELL, M.D.

WORCESTER, MASS.

THE cow is the foster mother of our civilization. And fortunate are we in being able to secure the services of this humble animal in our endeavors to arrest the most important cause of race suicide. For our greatest menace in this direction resides in the fact that an alarming proportion of infants must be vicariously nourished at some period of their development by the cow.

Owing, on the one hand, to that sinister development of our industrial system which compels many women to engage in competitive factory labor, and the invasion by women of almost every field of human activity; and, on the other hand, to the unwholesome influences surrounding those immersed in the fatuitous struggle for social supremacy, we find that each year rewards us with a larger percentage of women who are unable to nurse their children.

One way, then, of registering the progress of civilization is in noting the constantly increasing proportion of infants in the rearing of which artificial feeding plays an important part.

It may, with some truth, be urged that owing to the educational influence of mothers' clubs and the like, and the entreaties of physicians, there is among a certain class of women possibly a greater desire to nurse their little ones; but of what avail is this inclination if their previous condition of servitude to a life not in consonance with this result, renders them physically unable to perform this important function? And it must be noted that this physical unfitness is not necessarily due to a failure on the part of the glands to which the duty of supplying lacteal fluid is assigned.

Many mothers are able to furnish for their children a fluid, but it can scarcely be designated as milk, owing to the fact that the blighting effects of unhappy or unwholesome emotions so common among wage earners, the over-worked housewife and the social aspirant render the milk entirely unfit for food.

To-day we live under high-pressure conditions, with accompanying wide fluctuations in emotional experiences, developing resultant temperamental effects notably prejudicial to the manufacture of a wholesome milk in the nursing mother. The chemistry of the emotions plays an important part in the welfare of the child.

It has been shown that as the result of vexation, disappointment, grief and kindred emotions certain highly organized chemical products are elaborated within the economy which find their way into the blood stream and thus into the mother's milk, rendering it more or less harmful to the infant receiving it. Hence, if it were possible during the period of lactation to transmute all women representative of the classes above indicated into wholesome, phlegmatic German peasant mothers, our milk problem in its multiform aspects would be wonderfully simplified. The present social order not only makes impossible such conditions, but we must calmly face a future in which maternal inefficiency in this regard will be even accentuated.

Some of us believe the solution of the vexed question of the overpopulation of the earth is resident in this problem of artificial feeding, particularly as certain statistical relationships seem to be springing up between the notorious modern birth rate and inefficient maternal nourishment, and we are learning that unsatisfactory as is artificial feeding at its best and perilous as it may become, it is, in any event, much more likely to be productive of good results than the attempt to nourish an infant on the milk of the mother physically, occupationally and temperamentally unfit.

Again, our apprehension must not be transformed into despair, for unremitting educational endeavors will ultimately insure a better milk supply and greater intelligence in its use. So while milk is regarded the most perfect of all foods for the young or old, in sickness or in health, the milk problem is virtually the children's problem, for cows' milk, modified in accordance with the requirements of each particular case, has been found to be the only practical method by which nature's plans for early nourishment of the human infant may be successfully imitated. Any attempt at the solution of this question, therefore, which fails to emphasize our guardianship of the interests of the child would be calamitous.

Surgeon-General Walter Wyman of the Public Health Service says:

> The steady decrease in general mortality does not apply to infants. It is recognized that gastro-intestinal disease is the largest single factor determining infant mortality. This enormous loss of potential wealth is of grave concern to the state and worthy of most careful consideration.

Further he says:

> Dr. Eager gives figures to prove that the high infant mortality may be attributed almost entirely to impure milk.

Inasmuch as one child in every twenty in our large centers of population dies before five years of age of maladies traceable directly or indirectly to contaminated cows' milk, it may be well to outline very briefly some of the properties of this indispensable food and a few of the problems associated with its production and supply.

Milk is at once the most important and the most perishable of all food products. Fresh milk is the most perfect mechanical emulsion known and contains roughly proteids (albuminoid substances equivalent in nature to the white of the egg) fat, in the form of minute globules which are later represented as cream, milk sugar, certain mineral salts and water. There is more or less fluctuation in the proportion in which these substances appear in all milks, particularly the milk of cows, owing chiefly to the development (in some instances covering periods of many hundred years) of certain breeds of cattle, possessing, among other qualities, certain characteristics as milk producers. I say chiefly to the development of breeds, because repeated experiments with various breeds have shown that it is not possible to alter materially the proportion in which the various constituents of milk appear in the milk of any given cow by any process of feeding yet discovered.

Improved methods of feeding increase the total *quantity* of the output, but not materially the quality, and any attempt to force by feeding an increase in the percentage of any one of the ingredients in the milk (particularly the fat content) may increase slightly for a short time such content, but it soon drops to the normal for each cow, and the experimenter has run the risk of ruining the animal experimented upon.

A popular fallacy prevails which enshrines in the minds of the uninformed the belief that milk having a large percentage of fat is rich milk, and hence, the best milk. Milk rich in fat and the best milk from both a physical and a chemical view are not synonymous terms, either as a matter of domestic economy or as applied to its use for infants. While all good milk must possess fat, the consideration of the amount thereof from a nutritive standpoint is second to that of the proteid content except in a certain few selected cases, which rarely include babies or young children.

Dr. J. A. Gilbert, writing in *The Medical Record* (New York), takes the view that this devotion to "rich" milk has no logical basis. In our earnest search after a fat milk, he says, we have probably gone too far. To quote from an editorial in *The Hospital* (London) which notes Dr. Gilbert's opinion appreciatively:

> The milk which is richest in cream is not, therefore, the most nutritious, for the very simple reason that a rich milk is less easily digested and absorbed than a milk in which the fat percentage is low. As far as its other constituents are concerned, a milk poor in fat is as valuable a food as a milk rich in fat.

Owing, then, to ignorance or personal interest, recent discussion of the milk problem throughout the land has revolved around the percentage of fat in milk and undue prominence has been given this phase of the question.

Protein is the most important nutritive content in all milks, and is the one toward which breeding efforts and the attention of the consumer should be directed. As protein, the tissue former, is the most valuable constituent of milk, it follows that an endeavor to insure a high percentage of this indispensable food element should be the aim of any legislative enactments having in view the establishment of milk standards (of which we hear so much in this day) and not the maintenance nor increase of the fat content. And when it is understood, moreover, that as the fat content of milk increases, the tendency probably is toward the decrease of the proteid content, the folly of this course becomes patent.

Legislative measures referable to the production, transportation, sale and consumption of milk have had and will continue to have a most important, direct and indirect influence upon the character of the herds supplying the milk to the several communities in which such legislation is operative.

As laws represent the will of the majority and as the majority in this instance are the consumers, it behooves us, as such, to understand what is desirable in the matter of milk and then through educational effort work toward the attainment of it.

A word here regarding the leading characteristics of breeds of cattle may not be amiss. All cattle may be roughly divided into three general classes according to the purpose for which they are designed—the beef breeds, the general purpose breeds and the dairy breeds, with the last of which only we are concerned. The dairy breeds are again roughly divided into two great classes.

First, those who give large quantities of milk containing a normal proportion of fat divided into small globules. Of this type the Holsteins and Ayrshires are examples.

Second, those in whose milk a large percentage of fat is found in the form of large globules but who in general are somewhat delicate and comparatively small milkers.

Jerseys and Guernseys are typical of this class.

Before the introduction and general use of the separator, a device which separates the cream by centrifugal force from the fresh milk, the dairy breeds represented in the second class were in great demand, because with their milk the cream rose quickly to the surface on standing and was easily skimmed. The skimmed milk, however, of these breeds has the bluish color, familiar to all housewives, and is possessed of small nutritive value. Excessive fat production having been developed at the expense of the food value contained in the whole milk. Moreover, the fat globules are large, being about three times the size of those of the breeds representative of the first class, and hence much more difficult of digestion by children and most invalids.

In this connection, Chas. W. Townsend, M.D., of the Boston Floating Hospital, says:

> The *quality* of the fat of Jersey and Guernsey milk, aside from its *quantity*, is in some infants a cause of digestive disturbance; I have many times seen babies gain but slowly and show fatty stools on Jersey milk modifications, even when the percentage of fat was low, while the same babies gained rapidly and digested well the modifications having the same amount of fat, made with the milk of Ayrshire, Holstein or common red cows.

Since centrifugalization was introduced much more attention has been given to breeds giving more rational milk, for the separator removes as easily and at the same cost the fat from a low as a high percentage milk. Hence, the effort as indicated has been to develop breeds which would produce skimmed milk which was nutritious and regarding the manifold virtues of which as a food we need not enter into here.

So highly developed are some of these breeds of the first class that it is worthy of note that many individuals are to be found that will give their weight of milk each month and total butter production for the year, equivalent to one half their weight.

Hence, we find in breeds representing the first class, namely, the Holsteins and the Ayrshires, the qualities particularly desirable in the family cow, inasmuch as their milk is best for infants, and furnishes a perfectly balanced ration alike for older children and adults.

Again, important as are the chemical analysis of milk and urgent as is the necessity of its being delivered fresh and uncontaminated, the question of the vigorous health and temperament of the individual cow is quite as vital.

Let us then again consider the relative merits of the two classes of dairy cows as heretofore indicated, in relation to their claim for excellence in this indispensable particular. Mention will be made only of the leading breed in each class in order to emphasize the illustration.

It is a well-known fact that the Jerseys, as bred and cared for in this country, have a highly irritable nervous temperament, and are more difficult to feed, rear and manage than any other breed.

The Holsteins, on the contrary, are a large, healthy breed of placid temperament, great constitutional vigor, enormous digestive and producing capacity, comparatively resistant to disease, and flourish to a high degree in our trying climate. The same qualities which commend the wet nurse in the performance of the function which the child's natural mother is unable to perform, are those which should commend to the community the cow which now, more than ever, sustains to the infant population the relationship above indicated.

Common knowledge independent of scientific observation sustains the fact that a nurse with poor or delicate digestion, sensitively and highly organized, irritable nervous temperament, doubtful vital resource or resistance, is entirely unsuitable to rear a child. The same is true of the cow, and her individual adaptability must now be subjected to the same scrutiny. Many an infant has had its life imperiled or has been lost owing to its receiving its nourishment from a nurse who has suffered from disappointment, anger, hysteria, indigestion, lack of exercise or the like.

Much of our artificially fed infant mortality is due, directly or indirectly, to the presence in cows' milk of similar poisons generated in nature's wonderful laboratory and as defiant of test-tube analysis as are those other qualities in the milk of strong, hardy cows which, for want of better names, we designate as vital energy or vital force.

Speaking of vitalizing power in the milk of certain cows as compared with others, Professor Carlisle, of the Wisconsin Experiment Station, says:

> The point I wish to make here is that there is such a thing as vitality in milk, and that it is of equal if not greater importance than is chemical composition especially for the milk supply of cities. And there can be no question but that the vitality of the milk is closely associated with the vitality of the animal producing it.

The effect, then, of laws requiring a high percentage of fat will be to put a ban upon the most sturdy, healthy, normal, productive and useful breed of cows the world has ever known, for they are to be found in every country of the globe and probably produce more milk and by-products than all other breeds combined. It will encourage the sale of the milk product of a breed which is neither hardy nor vigorous; which is probably more susceptible to tuberculosis and other diseases, owing partly to the fact that their delicate constitution requires housing more months of the year than any other breed; a breed giving a milk not only entirely unsuited to the purposes of artificial feeding of infants, but possessing excessive fat and other deleterious properties to such a degree that many of the cows of this breed are unable to rear their own calves; a breed originating in a salubrious climate, reared with the tenderest care, and brought to this inclement land to be exposed to conditions unnatural to them or their ancestors and therefore resulting in a milk product which, according to modern standards, is undesirable in many ways.

Many state institutions throughout our commonwealths maintain herds of Holsteins, some of which are among the finest in the land, in the confident belief that it would be impossible to supply such an abundant quantity of highly nourishing milk through the medium of any other breed.

Thomas Morgan Rotch, M.D., the distinguished authority on the diseases of children, speaks as follows regarding the value of the milk of this particular breed:

For instance, good Holstein milk is at times not salable on account of its total solids not coming within the limits of the law (Massachusetts State Standard). The law demands during winter 3.70 per cent. fat and 13 per cent. solids, while in the summer 3 per cent. fat and 12 per cent. solids. As we all know, the Holstein milk, unless the cows are especially fed, falls below this standard. Now, from a medical point of view the Holstein milk is exactly what we find best for infant feeding and it is an extremely good milk for any one to drink.

The immense number of infants, however, who live entirely upon milk should be taken into consideration in this question, and I believe that the people should be allowed to buy this milk just as they should be allowed to buy a milk modified to suit a special infant who is being taken care of.

Too much can not be said or done to encourage the production and consumption of a food product which possesses nutritive elements of the right kind in the proper proportion, and nourishing qualities of such high value—a product which is essential to the proper development of the child, upon the future health of which the state becomes dependent for its prosperity, a product which has made healthy, contented and prosperous the nation, which for two thousand years has enjoyed its benefits.

As we have seen, no cow can obey the mandate of a legislature, no matter what liberty she may be allowed to exercise in the choice of her food. Some protection against adulteration and other forms of fraud in these selfish and greedy commercial days is necessary, but a standard based upon the total fat and total solids not fat, in milk, particularly when that fat percentage is placed so high that none of our most useful and healthful breeds can produce herd milk in compliance with it, simply defeats the object for which it was designed.

For example, the milk test at the St. Louis Exposition was probably the most scientifically conducted and most illuminating in results ever made in this or any other country.

Among others the following groups competed in the tests: twenty-five Jerseys, five Brown Swiss, fifteen Holsteins and twenty-five Short Horns, not one of which produced milk up to the legal standard established by some states, and yet these cattle had been selected and fitted for an international exhibition, and were fed, groomed and tutored by experts in the art of milk production. Some of the very animals, valued perhaps at several thousand dollars, are producing milk in several different commonwealths to-day, which if sampled by the state inspector could put its owner in jail for violation of the law. Moreover, when we understand that the relative percentage of fat and solids not fat, in milk, varies in each cow with the period of lactation, time of day when the sample is taken, with the weather and seasons, the physical condition, and many other contingencies, and when we realize that two quarts from the same cow can differ; also two quarts from the same milk pail and mixing tank, some of the difficulties in establishing a just, arbitrary standard may be appreciated.

It is difficult to induce the public to realize that refined methods of analysis, the more careful attention to breeds and breeding, the great difficulty of supplying from considerable distances, the ever-increasing urban demand, the introduction of centrifugalization and other important considerations have entirely changed the complexion of the milk problem within a very recent period.

Many of us do not realize that much of the milk consumed in our large cities is taken from herds kept as far as 300 miles or more from the consumer, and when it is delivered to him is frequently forty-eight hours old. The problems surrounding the transportation of such milk in the summer season may be in part appreciated when we know that the presence of 5,000 bacteria to the cubic centimeter is considered a reasonably low count and that under favorable conditions this number is capable of doubling by geometrical progression every half hour.

Samples of commercial milk taken in New York city recently showed 35,200,000 bacteria to the cubic centimeter; London, 31,888,-000; Washington, 22,134,000. That seventy-eight typhoid germs in one cubic centimeter of milk increased in seven days to 440,000,000 furnishes an illustration of the possibilities in this direction, and when one realizes that one cubic centimeter is equivalent to about sixteen drops, some idea may be gained of the bacterial population of much of the milk we drink.

Milk removed properly from a perfectly healthy cow, and kept in receptacles previously sterilized, contains practically no bacteria, and may at a low temperature be preserved for days without material change. When, however, these precautions are not observed the results are as above indicated. Not all these germs are harmful, but many varieties are exceptionally prejudicial to the health of children. Each of 500 epidemics recently investigated, including typhoid fever, scarlet fever and diphtheria were found to be caused by contaminated milk. That 11 per cent. of milk samples examined from Washington contained tuberculosis germs need not be considered as exceptional and can be verified by the examination of data of a similar nature from other cities. And when we understand that the milk supply of New York city, for example, is derived from the product of 35,000 farms and shipped from 700 creameries located in six different states, it is easy to appreciate some of the difficulties surrounding the protection of the community from the sources of infection contained in milk.

In recent years the prominence given to tubercular disease in cattle, with the consequent appearance of the tuberculosis germ in the milk of such cattle, has entirely overshadowed the importance of certain other diseases in cows, likewise accompanied by the presence in the milk of cows so suffering of enormous numbers of bacteria characteristic of such diseases. I refer particularly to the disease known as "Mastitis," an inflammation of the udder accompanied by the presence of certain bacteria largely of the pus-forming type which are discharged with the milk in enormous numbers.

While possibly a smaller number of cows suffer from this disease than from tuberculosis (and herein probably lies the reason why this important source of infantile mortality has been overlooked), many cows not only suffer from repeated acute attacks in which far greater numbers of these bacteria are eliminated with the milk than tubercular germs in pulmonary tuberculosis or even tuberculosis of the udder, but not a few suffer from a more or less intractable, chronic type of this malady which renders them a never-failing fountain of mischief.

Probably the major portion of the grave intestinal disturbances of children are due directly or indirectly to the presence in milk of the bacteria characteristic of this disease and the ptomains, toxins and kindred substances which always accompany certain types of bacteria activity. And notably is this true of milk, for it is a most excellent example of what is known technically as a culture medium, meaning a substance favoring in a high degree bacteria development and growth. Some one says: "Yes, while this is all very bad we can protect ourselves by pasteurizing or sterilizing our milk." While either of these processes properly carried out will destroy the germs or for a few hours prevent their activity they can not destroy the ptomains or like highly organized poisons already present, and as dangerous to human life as they are crafty in eluding chemical analysis.

Pasteurization, then, the proper execution of which requires much skill and training, removes from contaminated milk but part of the danger while its palatability has been impaired and its nutritive properties somewhat altered, and we are obliged to drink the carcass of millions of bacteria still suspended in it. The tendency, moreover, of pasteurization is to put a premium upon dirt, which gains entrance to milk chiefly through careless methods in milking and caring for milk after it leaves the cow which carries with it a great multitude of bacteria and is the most important source of bacteria contamination of milk.

It has been computed that the people of the City of Berlin drink in one year many hundred pounds of cow-barn filth suspended in milk.

Milk so produced as to be free from dirt (unhappily not the milk of commerce) may be considered also comparatively free from bacterial growth.

Pure milk, fresh milk produced free from germ and dirt contamination in the stable and during handling and transportation, is the birthright of our children, is what we all desire and is the goal toward which the various boards of health, cattle inspection bureaus and similar agencies of our commonwealths are striving for against heavy odds.

Two great obstacles stand in the path:

1. The difficulty, even under repeated inspection of premises on which milk is produced (inspection in some instances emanating from four or five separate sources) to induce the producer to adopt cleanly methods of production.

2. The increased cost to the consumer of milk so produced, a cost which the poor man can not and the well-to-do are disinclined to meet. For in many of our states it is doubtful if such milk as we would all like to use could be delivered at our doors, under the conditions of increased cost which prevails to-day, at 15 cents a quart and allow the farmer and the retailer each a reasonable profit thereon; for in farming, as in other lines of business, cost of production must include interest on investment, taxes, depreciation, labor, raw material (hay, grain and the like) insurance, and similar charges.

But what remedy may we hope to apply to extricate ourselves from the present dilemma? Rather than fritter away the money and energies of the various states in trying to maintain standards for fat and solids not fat which are not only impossible of attainment, but a constant menace to the farmer and a prolific source of irritation and discontent to all concerned in the milk industry. Let us now concentrate our efforts upon an endeavor to insure a pure milk supply for the children. This can best be done by taking the machinery of the state boards of health and kindred agencies now employed in cattle and milk inspections and direct their activities along the lines of a certified milk supply which has been applied with measurable success in connection with certain cities—the plan being to enlarge the scope of the work, as at present conducted, so as to include all the dairies supplying the commonwealth with milk whether situated within or without the state.

Certified milk means that a dairy has been properly inspected by trained and competent officials who give to the owner thereof a certificate allowing him to place upon the containers of milk leaving his farm (for a certain period until a subsequent inspection is made) a label indicating that the milk is absolutely clean and produced under sanitary conditions by a healthy herd.

This plan minimizes the technicalities and red tape ordinarily attending work of this nature and promises to vouchsafe to us and our children a milk supply in character consonant with the demands of the civilization in which we live, but it can not be secured unless a majority of us demand it and are willing to pay for the additional expense which it entails.

SHALL OUR FOREST WEALTH BE DESTROYED?

BY THOMAS ELMER WILL
SECRETARY OF THE AMERICAN FORESTRY ASSOCIATION

IN the sunny southland, stretching from Pennsylvania in the northeast to Alabama in the southwest, are the Southern Appalachian Mountains. These constitute not a single ridge or chain, but a zone or belt composed of numerous parallel ridges, as the Alleghenies, Blue Ridge, Black, Unakas, Smoky, etc. Connecting these ridges, often, are cross ridges equaling in cases and even exceeding the longitudinal ranges.

Surmounting these ranges at many points are lofty peaks. Of these the chief, Mt. Mitchell, is 6,711 feet high; 46 more, a mile or more apart, with 41 miles of divide, rise to an altitude of 6,000 feet, while 288 others, with 300 miles of divide, reach a height of 5,000 feet above the sea. Among these may be mentioned, in the Blue Ridge, Grandfather Mountain, 5,964 feet, Pinnacle, 5,693 feet and Standing Indian, 5,562 feet high. In the Smoky Mountains, Mount Guyot reaches a height of 6,636 feet, and Clingmans Dome, 6,619 feet.

"Between these groups of mountains and far below them, though still at an elevation of 2,000 feet or more above the sea, are the numerous narrow valleys of this region." Many of them are marked by great fertility and beauty.

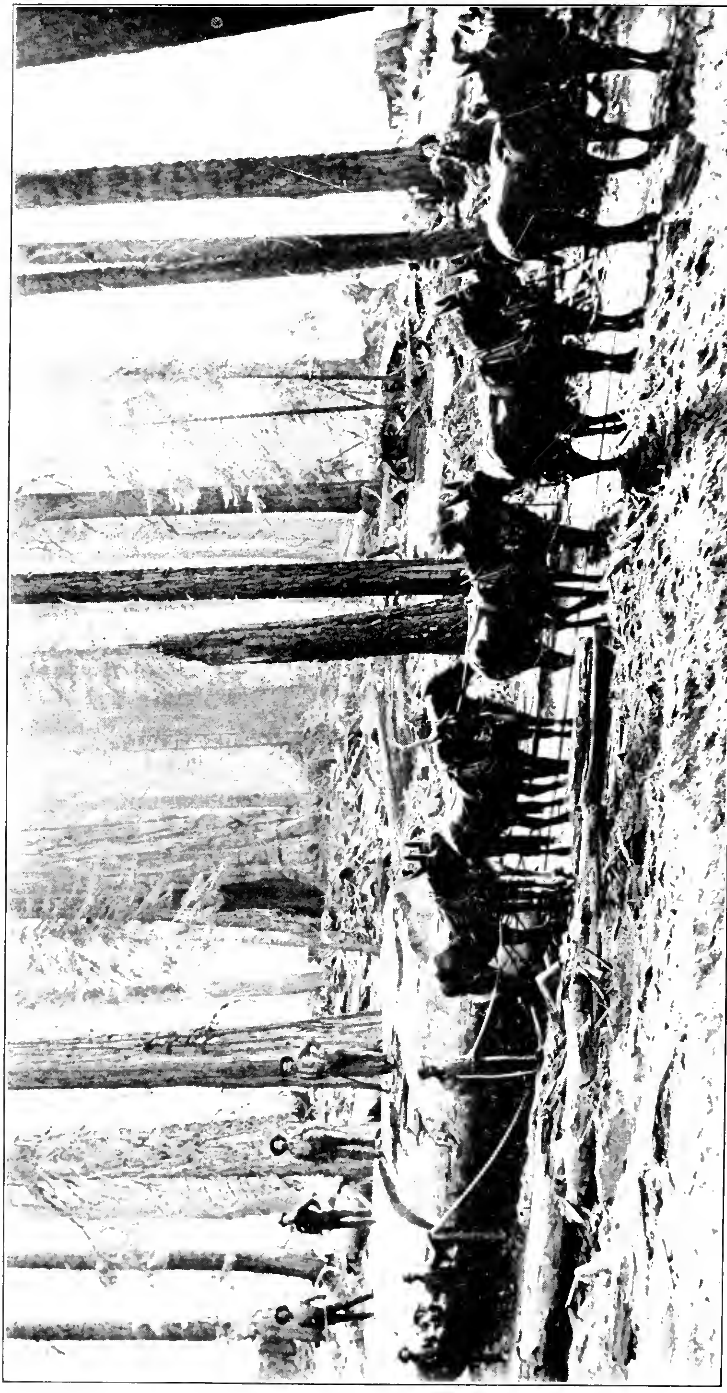
Save on the highest peaks, or on the slopes where man has interfered, these mountains are clad with a magnificent growth of forest. Near the bases are found oaks, hickories, maples, chestnuts and tulip poplars, suggesting in size the great trees of the Pacific coast. Higher, one passes through forests of great hemlocks, chestnut oaks, beeches and birches, and, still higher, through groves of spruce and balsam. Near the tops, the balsams become dwarfed and are succeeded, largely, by clusters of rhododendron and patches of grass fringed with flowers.

In this region, ranging from 60 inches in Georgia to 71 inches in North Carolina, occurs the heaviest annual rainfall in the United States, save on the Pacific coast. The water thus precipitated finds its way to the sea, east, west, southeast or southwest, through practically all the important rivers of the south. The Southern Appalachians thus constitute the watershed for, practically, the entire region below the Potomac and Ohio and east of the Mississippi. The descent of the water from the mountainsides is marked by some of the most beautiful cascades and waterfalls that ever gladdened human sight. Among

Planting Pine Seeds, San Gabriel National Forest, California.

these may be named the Falls of Elk Creek, near Cranberry, N. C., the Upper Falls of the Whitewater River, the Lower Cullasaja Falls of Macon County, N. C., and the Toccoa Falls of Habersham County, Ga. Thus, with infinite variety of mountain and valley, forest and stream, cascade and waterfall, beetling crag, bold precipice and dizzy gorge, this entire region presents a scene of transcendent natural beauty and sublimity.

As a national park and recreation ground this area has no equal in the United States. Unlike the splendid but remote Yosemite, it is within twenty-four hours' ride of 60,000,000 people. With modern transportation facilities the cities of the east—New York, Boston, Philadelphia, Baltimore, Washington; of the south—Charleston, Atlanta, New Orleans, Nashville, Louisville; of the middle west—Cincinnati, Cleveland, Indianapolis, St. Louis, Kansas City and Chicago—are almost at its doors.



Millwood, Cal. Logging a Big Tree.

Such a recreation ground is a crying national necessity. As a people, we work too much and rest too little. Herbert Spencer, when in America years ago, declared that we had heard enough of "the gospel of work," and that what we most needed was "the gospel of relaxation." Since then the situation has grown worse rather than better. It is the old story of "all work and no play"; and the effects are seen in nervous prostration, insanity and suicide.

Again, from the economic standpoint this area is invaluable. It contains our last remaining, important stand of hard woods. Forest Service statistics, the prices of lumber and all wood products—mounting by leaps and bounds—and common observation unite in testifying that our timber resources are being consumed and wasted in prodigal fashion and at a startling rate. The Southern Appalachian forests, however, the hand of the spoiler has delayed to enter; and, though the supplies, once thought inexhaustible, of New England and the Great Lake regions are practically gone, this area still contains a vast and priceless stock of the choicest timber on the continent.

We have heard of the "new south." It is the industrial south; the south of the railroad, the furnace, the loom and the spindle. From the purely agricultural, this section is rapidly entering upon the manufacturing stage. Irrespective of the question of labor, for such activity it enjoys some special advantages. Its staple, cotton, is near the mill, and its water-power facilities are magnificent.

Like many other things, power is a creature of evolution; first, it manifests through human strength; then, through "the energizing of brutes"; later, through wind and water crudely applied; and then, as the Yankee said, through water "biled," releasing, thus, the titan, steam, at whose feet, it has seemed, the very earth lay prostrate.

But the waning of the steam-engine is already in sight. New powers are appearing on the scene; the next of which, we may well believe, is electricity.

What a coal vein is to the steam-engine, a waterfall is to the dynamo.

As indicated, the Southern Appalachians abound in magnificent falls; from these, electric power can be developed cheaply and in great abundance. With the introduction of means of transmission it now becomes possible, instead of carrying the plant to the power, to bring the power to the plant. The gain is obvious.

The possibilities of electric power as applied to manufacturing in the south may be appreciated when it is known that North Carolina, South Carolina and Georgia alone maintain cotton mills operated by water power which produce annually a product valued at over $60,000,000. "The water power of this southern region already developed or being developed is estimated at 500,000 horse-power. The unde-

RANGERS HAZZARD AND BROWN, OF LEADVILLE NATIONAL FOREST, COLORADO.

veloped water power is probably not less than 1,000,000 horse-power more."[1]

The mighty interests here indicated are bound up with the preservation and perpetuation of the forests upon the Southern Appalachian Mountain slopes. The value of water power is limited by the low water flow. The question is not, How much water is discharged annually? nor even, How great is the average flow per month? but How great is the minimum? Hence constancy and a reasonably large volume are essential.

These are insured by the preservation of the forests, for the forest mulch holds back the water precipitated by rainfall and thaws, and discharges it gradually the year round. If, on the other hand, the mountainsides are stripped of their vegetation and then, by fire and floods, denuded of their soils, the water which, gradually supplied, might have driven the mills, now descends in disastrous floods, only to be followed by long periods of low water.

Agriculture is, of course, largely dependent upon natural irrigation from the rivers fed from these mountains. To it the alternation of flood and drought is as disastrous as to manufacturing by water power. Similarly, the great transportation interest of the south is intimately concerned. Its profits are directly dependent upon tonnage, and tonnage is dependent upon the productiveness of the region served.

What, now, is the situation of the south as respects the conservation of these interests?

[1] U. S. Senate report No. 2537.

Three foes menace the forests. First is the exploiter of forest lands. Chief among these is the small mountain farmer. In a region never designed for agriculture he endeavors, with primitive appliances and obsolete methods, to grub out for himself a scant subsistence. To do this, he must sacrifice the trees.

Making a mountain farm, however, is quite a different thing from maintaining it as a farm. Under the crude culture practised, a period of from five to twenty years suffices to exhaust the land and send the farmer farther up the slope. Here he repeats the process; and thus, as he ascends, he leaves in his wake a tract of desolation, for the swift-descending rains soon convert these cleared areas into irreclaimable gullies.

Second come the exploiters of the woods themselves. Among these may be mentioned the turpentine man, who, by a crude method of extracting the resin, though a far less hurtful might be employed with greater profit to him, is rapidly despoiling large areas of forest. The tan-bark man, next, strips from the trees their bark, and leaves their unused hulks to cumber the ground. The pulp man clears the ground of all trees—old, young, large and small—and so prevents the forest from renewing itself. Finally, as the bonanza farmer attacks the Dakota wheat-field, the lumberman, with methods long tested and equipment perfected, invades the forests, and the monarchs fall before him like grain before the sickle of the harvester.

Next and most terrible, sometimes from accident, sometimes from design, comes the fire. In the slash and wreckage left by wood-cutters

STILL HAND-DIPPING ROSIN FROM VAT INTO BARRELS. OCILLA, GA.

it rages as in a Chicago or a San Francisco; and in its seething caldron disappears not only the last vestige of wood but the very soil itself.

Last of all follows the rain. This, falling upon denuded slopes, is transformed from a blessing into a curse; for whatever movable thing remains is swept by it down the mountainsides to glut the streams and harbors and insure the overflows which convert the streams of the south into so many Hoang-hos or "rivers of sorrow."

In the face of this process almost every legitimate interest of the south is menaced. Natural beauty disappears like the splendor of the butterfly clutched by the schoolboy. Agriculture, manufacturing, transportation and the industries tangent thereto are doomed to pro-

Dinkey Engine and Geared Locomotive, Douglas Spruce District. Operations of Simpson Logging Co., Mason Co., Wash.

digious losses and, in cases, to extinction. The whole region involved is threatened.

And the remedy? President Roosevelt, quoting and endorsing Secretary Wilson, has put it tersely: "The preservation of the forests, of the streams, and of the agricutural interests here described can be successfully accomplished only by the purchase and creation of a national forest reserve." A cluster of thinkers, writers and publicists have borne similar testimony.

And why should a national forest reserve prove a remedy?

For this reason. There are in operation in our industrial life to-day two principles. The one is that of private initiative, individual profit and *laissez faire;* the other is that of public ownership, and administration for the public good. That the first has achieved victories, belted continents, surmounted Alps, tunneled mountains and worked miracles let us concede. Nevertheless, it has its limitations. That this is true, experience, with its insurance investigations, rate bills, meat inspection, pure-food legislation and the like, is daily making clear. In the field of forest administration and exploitation—notably when the forests in question control important river sources—the limits of *laissez faire* were long since, and after fearful public loss, recognized in Europe.

In such a case, the individual initiative principle works directly counter to the public good. Private interest impels the doing of almost all the mischievous things above enumerated: clearing slopes for farm-

The Ruins of a Brick House Demolished by the Freshet of May 21, 1901. Bakersville, Mitchell Co., N. C.

ing, stripping trees for bark and leaving the trunks to rot, cutting clean for pulp, and felling at once for lumber purposes trees which should be left indefinitely on the ground. Abusing the exploiter is gratuitous, vain, unjust. His "greed," so called, and his disregard for public interests are no greater than those of other men. He is simply following the principle whereby successes have been achieved and fortunes won on every side; but, in so doing, he is, nevertheless, mining and sapping at the very foundations of national well-being.

The second principle, on the other hand, impels the quest not for

THE SHAPE OF THE CLOUDLAND MOUNTAIN, BETWEEN GREEN COVE AND THE HEAD OF BEAR CREEK, SHOWING LAND SLIDES IN PASTURE. These were made in the storm of May 21, 1901, and covered from 100 to 500 square feet. Mitchell Co., Cal.

private profit and individual fortunes, but for the general welfare. It views a question from the standpoint not of the individual, but of the community. It recognizes that the nation which would hold its place in the world struggle and in universal history must husband its natural resources and raise the general level of its average citizenship. Viewing a forest-covered slope, the representative of the private interest principle says: "Here a principality may be won. Come, see and conquer!" But the exponent of the public-interest principle says: "No; your present, petty gain can be reaped only by irremediable public loss. The whole is greater than any of its parts. The public safety is the supreme law. The government stands for all the people. In their interest, therefore, we encircle this area with the ramparts of public protection. To private initiative we say, 'Thus far shalt thou come, but no farther.' For the nation's sake this territory shall be conserved and forever publicly guarded and administered."

The present national forest area of the United States now exceeds the combined areas of New England, New York, Pennsylvania, New Jersey, Delaware, Maryland, Virginia, the District of Columbia and West Virginia—all west of the Mississippi. Already the policy is amply justified by its fruits. Now let it be extended.

For the establishment of a national forest to protect the grand old white hills of New Hampshire and the great commercial and manufacturing interests dependent thereupon an argument may be made almost or quite as strong as that for the protection of the Southern Appalachian forests.

Nine years ago the struggle began for the establishment of national forests first in the southern Appalachians, and then in the White Mountains. In the fifty-ninth Congress this effort almost succeeded. The bill was unanimously passed by the Senate and reported without dissent for passage by the House Committee on Agriculture. The president approved it in advance and strongly urged its passage. Through the opposition, however, as is generally understood, of the speaker, this bill could not be brought to a vote in the House. The fifty-ninth Congress did, however, appropriate $25,000 for surveying the Appalachian-White Mountain area. In the summer following, the survey was made and the report was made at the first session of the sixtieth Congress. Appalachian bills were promptly introduced into both Houses. The House bills went to the Committee on Agriculture. Here, on January 30, a hearing was had. It lasted an entire day and was of a character apparently to convince all who were open to conviction. Later, however, the constitutional question was raised and the bill was sent to the House Committee on Judiciary. A hearing was had before this committee on February 27, the arguments for and against

A Serious Fire was stopped at this Lane. It is 60 feet wide, and was hastily cut through a Dense Sapling Stand. Litter scraped up on the right. Beede, Adirondack Mountains, N. Y.

LINVILLE RIVER AND FALLS, showing Steep Rocky Gorge, whose Walls are from 500 to nearly 2,000 feet high. Byums Bluff, Mitchell Co., N. C.

the constitutionality of the measure being presented. Then came the familiar delay. Meanwhile boards of trade, chambers of commerce, women's clubs, civic and patriotic organizations and individuals without number representing every section of the country, every political creed and practically every social class and interest, poured in letters, telegrams, petitions and resolutions, as one congressman declared, "by the millions." The Senate passed the bill.

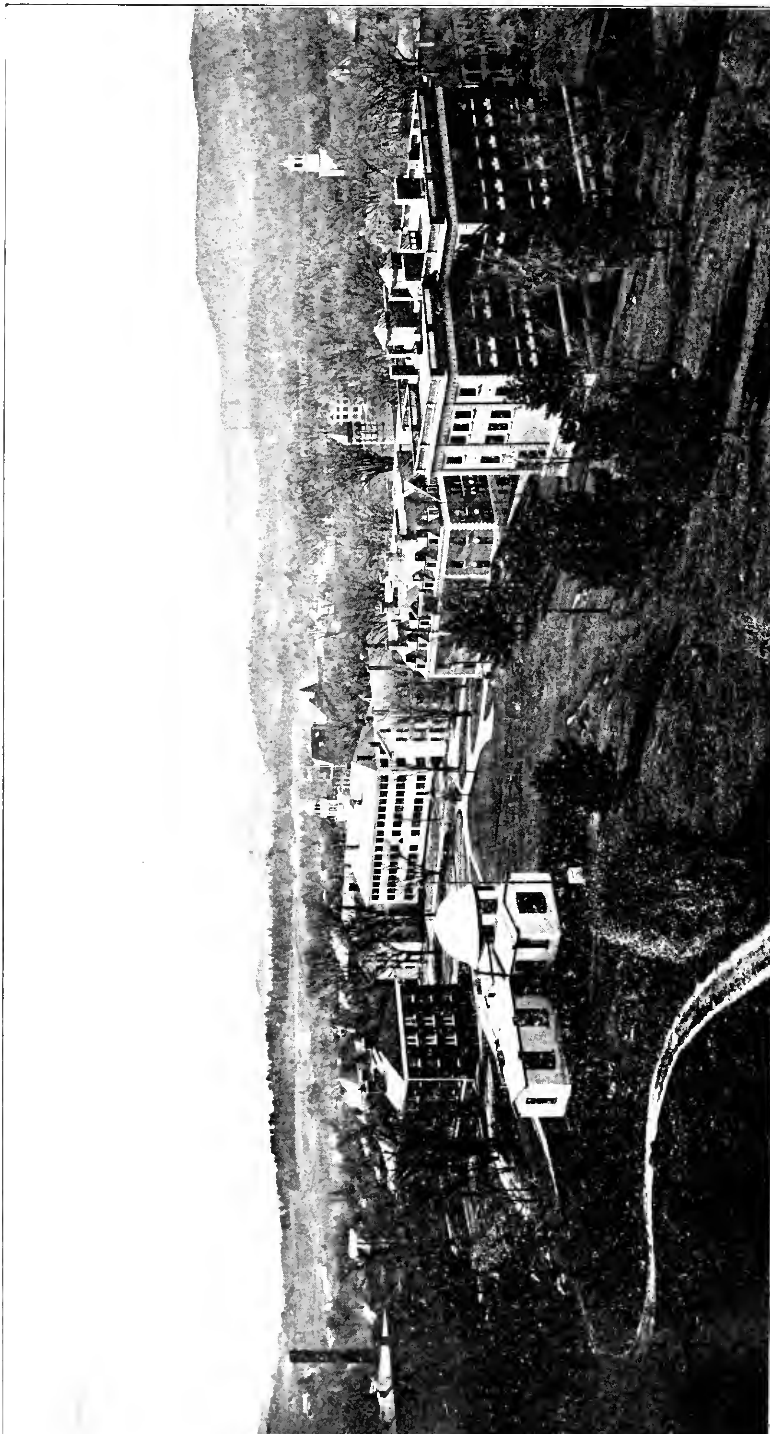
The House Committee on Judiciary, by unanimous vote, on April 22, decided as follows:

Resolved, that the Committee is of opinion that the federal government has no power to acquire lands within a state, solely for forest reserves; but under its constitutional power over navigation, the federal government may appropriate for the purchase of lands and forest reserves in a state, provided it is made clearly to appear that such lands and forest reserves have a direct and substantial connection with the conservation and improvement of the navigability of a river, actually navigable in whole or in part; and any appropriation made therefor is limited to that purpose.

Resolved, that the bills referred to in the resolutions of the House, H. R. 10,456 and H. R. 10,457, are not confined to such last mentioned purpose, and are therefore unconstitutional.

This decision, apparently adverse, was really favorable. The bills were at once modified to meet the requirements of the Judiciary Committee and reintroduced. The Agricultural Committee of the House, however, reported a new bill, providing only for a Congressional investigation or "junket" during the recess. This passed the House, but went no farther.

Effort should now be concentrated on the House, to secure the passage, by that body, of the excellent Senate bill. Already the tide of public opinion has risen high in favor of this legislation. It is still rising. An earnest, united, systematized effort, by all concerned, should bring success at the next session of Congress.



DARTMOUTH COLLEGE AND THE SURROUNDING COUNTRY

THE PROGRESS OF SCIENCE

DARTMOUTH COLLEGE AND THE SUMMER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The American Association for the Advancement of Science in planning a special summer meeting had in view a visit to an educational institution of interest in a region attractive in the summer time, rather than a convenient place for the presentation of scientific papers. The meeting was entirely successful from the point of view of place and environment, and the fact that the scientific programs were not extensive was scarcely a drawback. Nor did the small attendance interfere seriously with the pleasure of those present, though it seems a pity that only two of the eleven sections of the association organized and that but few of those interested in sciences other than physics and geology made the meeting an occasion to visit Dartmouth College and meet their friends.

It is perhaps true that the holidays are not the best time to visit a college, which should be regarded as its men and their work rather than as its buildings and equipment. But in any case it is not possible for a visitor to do more in a couple of days than obtain a general impression. Dartmouth is one of the oldest of our colleges and one of those which have grown most rapidly in recent years. It is in many ways a typical New England college, though its school of medicine and its graduate schools of engineering and affairs give it better warrant to bear the name of university than many institutions which assume this dignity.

Dartmouth College traces its origin to a school for the christian education of young Indians, opened in 1754; it received a charter with its present name in 1769. In 1819 a lawsuit between the trustees and the state of New Hampshire was decided which made the college independent of the state. Otherwise it might have been the University of New Hampshire, and this it may yet become. The reaction against state control which separated most of the eastern institutions from the state is not apparent west of the Atlantic seaboard, and it is by no means unlikely that through their colleges of agriculture and the mechanic arts or by adoption of one of the privately controlled institutions there may yet be state universities in each of the eastern states.

The Dartmouth Medical School began with the appointment of a professor of medicine in 1798. The Thayer School of Engineering was established in 1867 and the Amos Tuck School of Administration and Finance in 1900. These two schools are based on the college course, or rather, following the "Columbia plan," on the first three years, the last year of college and the first year of the professional school being identical. The college predominates, having 1,102 of the 1,219 students in the institution. In it the group system obtains and the possibility of completing the course in three years. Latin is required for the bachelor of arts degree, but not Greek. The students in the course leading to the bachelor of science degree, for which neither Latin nor science is required, are about half as many.

The catalogue says that the undergraduate life develops independence,

DARTMOUTH HALL. Used for the opening exercises and public lectures

COLLEGE HALL. Headquarters of the association originality, adaptability and broadness of mind, and probably uses with discretion "life" rather than "curriculum." The general spirit in the college is said to be excellent, and credit is given for this, as well as for the remarkable growth of the institution, to President Tucker.

As shown by the accompanying illustrations, the situation of Dartmouth among the New Hampshire hills is beautiful, and the campus and buildings make a pleasing impression. The original Dartmouth Hall, destroyed by fire, has been rebuilt effectively in brick. College Hall, a club house and commons, made excellent headquarters for the association. The scientific departments are well housed in the Butterfield Museum for the natural sciences, the Wilder Laboratory for physics, Culver Hall containing the chemical department and the Shattuck Observatory.

INTERNATIONAL CONGRESSES AND PERMANENT INTERNATIONAL BUREAUS

SCIENCE and commerce are breaking down the barriers between the nations. Commerce is at present competitive, having tariffs, navies and the rest as its adjuncts, but it will gradually become denationalized. Science is by its very nature cooperative, and international congresses advance in equal measure science and good will. Of somewhat unusual interest are the two international congresses which meet in Washington next month, one concerned with fisheries and one with tuberculosis. The fisheries are to a considerable extent subject to international control, and tuberculosis is the disease most likely to be mitigated by combined action against it.

The fisheries congress, which is the fourth to be held, opens on September 22, and after the sessions in Washington, special meetings will be held in New York, Boston, Gloucester and possibly in other places in New England. Other places which may be visited are Baltimore, the center of the oyster industry of Chesapeake Bay, and Chicago and other lake ports, where the fishery trade and methods of the great lakes, the most valuable fresh-water fisheries in the world, may be studied. Twelve governments have already accepted the invitation of the United States to be officially represented, and delegates have been appointed by the governors of many of the states. In view of the large number of persons who will attend as individuals or as representatives of important fishery societies, the congress promises to be important in its representative character, size and the value of its proceedings. The subjects included in the program are: Commercial fisheries; Matters affecting the fishermen and the fishing population; Legislation and regulation; International matters affecting the fisheries; Aquiculture; Acclimatization; Fishways; Biological investigation of the waters and their inhabitants; Diseases and parasites of fishes; Crustaceans, mollusks and other water animals; Angling and sport fishing.

The International Congress on Tuberculosis will meet on September 28, in the new building of the United States National Museum, where an extensive exhibit will be arranged. Six or seven hundred delegates from all nations of the world will be present, and the pathologists, physicians and students of social conditions will probably be numbered by the thousands. The members will include the most eminent students of the disease, and their discussions will lead to the diffusion of knowledge concerning causes and remedies and to renewed efforts to increase knowledge. The congress will also perform an important service by awakening popular interest and concern. More than 6,000,000 of those now living in the United States will die of tuberculosis, yet it is essentially a preventable disease. Both of the political parties have pledged themselves to increase the national agencies for suppressing disease and promoting the public health, and public sentiment will doubtless be further awakened by this congress.

International scientific congresses are leading to permanent international bureaus. Thus an International Association for Cancer Research has been founded at Berlin, to promote the investigation of cancer and the care of cancer patients, the collection and publishing of international cancer statistics, and the establishment of an international center of information on all matters concerning cancer research. Other objects of the association are the publication of an international technical organ and the organization of international cancer conferences. So far, thirteen states, including all the great powers except Great Britain, have joined the association, the seat of which will be at Berlin.

The International Institute of Agriculture was formally opened on May 23 by the king of Italy, who has given it a building and an endowment yielding $60,000 a year. The new building in the gardens of the Villa Borghese in Rome is said to be admirably suited to the purposes of such an institution. All civilized nations have joined in this movement, inaugurated three years ago, and it promises much for the promotion of agriculture throughout the world.

Permanent international bureaus must have a local home, and in addition to the two new institutions noted here there are others in London, Paris and Berlin. There are none in this country, and it is but proper that we do our share. The fisheries and research in tuberculosis and propaganda for its suppression would be proper objects for our government to promote, and it may be hoped that the approaching congresses will lead to the establishment of international bureaus at Washington for one or both of these objects.

SCIENTIFIC ITEMS

We regret to record the deaths of Mr. Henry Lomb, one of the founders of the Bausch and Lomb Optical Company; of Dr. Chamberland, subdirector of the Pasteur Institute: of Dr. Ostwald Seeliger, professor of zoology at Rostock, and of Dr. Rudolf Credner, professor of geography at Greifswald.

The Albert medal of the Royal Society of Arts has been awarded to Sir James Dewar.—Sir William Ramsay succeeds Lord Kelvin as a member of the Dutch Academy at Amsterdam.—Colonel W. C. Gorgas, eminent for his work on yellow fever, chief sanitary officer of the Isthmian Canal Zone, has been elected president of the American Medical Association.

Mr. Henry Phipps, of Pittsburg and New York, has made a large gift to the Johns Hopkins University for the founding of a Psychiatric Clinic. It provides for the construction of a hospital building, together with apparatus, and laboratories for the scientific investigation of mental abnormalities by pathological, chemical and psychological methods. Mr. Phipps will provide for the maintenance of a medical and nursing staff, including salaries for a professor of psychiatry and assistants and other expenses for a period of ten years. The total amount of the gift is withheld in accordance with the wishes of Mr. Phipps, but it is understood that it will considerably exceed half a million dollars. Dr. Adolf Meyer, director of the Pathological Institute of the New York State Hospitals, has accepted the professorship of psychiatry and the directorship of the hospital and clinic.

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THE BOTANICAL GARDENS OF CEYLON

By Professor FRANCIS RAMALEY
UNIVERSITY OF COLORADO

"AN English glass house glorified" is the description which a British friend of the writer gave to the garden at Peradeniya, Ceylon. And such it truly is. The brilliant foliage, the strange orchids and pitcher plants, the luxuriant ferns, the uncanny screw-pines, are just what one might see in a gentleman's conservatory—only more wonderful and luxuriant, grown taller and more fair. As a "show place" these gardens are not equaled anywhere in the world and as a place of scientific interest to botanists there are few rivals. Haeckel, the German zoologist and philosopher, said of his visit to Peradeniya that in the four days which he spent there he learned more botany than he could have learned at home in as many months of hard study.[1]

Ceylon has been described as a "dew-drop on the brow of India" and so far as position is concerned it is certainly very closely related to the Indian peninsula. In climate, too, and in the flora and fauna, the northern part of the island is strikingly Indian; the same may be said of the inhabitants. On the other hand, southern and central Ceylon has a climate of its own and the people as well as the plants and animals are quite different.

Peradeniya is situated in the center of Ceylon about seventy miles by rail from Colombo, the capital of the island. There is no town here, but only a post-office and a few scattered huts. The city of Kandy, however, is only three miles distant by rail or wagon road.

In going from Colombo to Peradeniya the trains are slow, but the traveler does not complain. Indeed, he would wish his journey lengthened, for the trip affords a four-hour introduction to tropical scenery which is nowhere surpassed. Any one can enjoy the journey whether

[1] Haeckel, "India and Ceylon," Ch. VI.

interested in the world of nature or in his fellow man. There are broad lowlands with cocoanut trees and fields of rice, alternating with patches of deep jungle in which the natives have cleared bits of ground and built their huts. In the higher altitudes tea fields and chocolate plantations are the rule. But here also are stretches of uncleared forest with trees of all heights and sizes, frequently some with hand-

Fig. 1. View in the *Pandanus* Quarter of the Peradeniya Gardens, Ceylon. Note the curious prop roots of these trees. From a photograph by the author.

some red or violet colored flowers standing out boldly amid a mass of dark green.

The garden at Peradeniya is only one of a number on the island. It is, however, the largest and most important. Here are the offices of the director of the gardens, whose duties correspond to those of a government secretary of agriculture. Other gardens and experiment stations, five in number, are established in parts of the island where differences in climate furnish altered conditions for plant life.

The Peradeniya garden is in the wet zone, or area of natural rain forest, at an altitude of 1,600 feet above the sea. With an annual precipitation of about 90 inches and a mean temperature of 75° Fahrenheit there are furnished the necessary conditions for luxuriant plant growth. A "dry season," extending through February, March and April, limits the growth of air plants hanging from trees, so that in this respect Peradeniya is not so interesting as Buitenzorg, in Java. The "dry season" is, however, not long enough to interfere with the growth of most plants and nearly all of the trees retain their leaves through this period. It is quite otherwise in the arid districts of northern Ceylon, where a monsoon forest with a considerable number of deciduous trees is the natural plant formation. Peradeniya, though rather too cool for cocoanuts or Para rubber, has a climate well suited to Castilloa rubber and to tea and chocolate, while palms of nearly all kinds thrive to perfection.

The garden was not originally laid out according to any system of plant classification, but was rather a beautiful park in which trees were planted for landscape effect. Now, however, the director,[2] is developing the garden according to systematic plans and making definite groups of plant families. Thus there are at present well-arranged plots devoted to palms, others to screw pines, others to cycads. It will necessarily be many years before the new plan can be fully carried out, for most of the plants in a tropical garden are trees. Indeed, the herbaceous garden forms but a small part of the whole.

Here, as in any first-class garden of the tropics, much is very new and strange to the botanist from temperate climes. Palms, screw-pines, giant bamboos, orchids and tree ferns, which he has known hitherto only from books or from the puny specimens of the plant house, become the commonplaces of every-day life. The sight of trees of the Composite family, Verbena family and many other groups represented at home only by herbs opens the eyes to some of the real wonders of tropical plant life. An interesting example is that of the "potato tree" belonging to the nightshade family. It does not produce potatoes, but its flower resembles that of a potato very much enlarged. At home we think of the nightshade family including only herbs and vines, but in the tropics it includes trees as large as our ordinary shade trees, such as elm and maple.

Nearly every kind of plant will grow at Peradeniya; tropical and sub-tropical plants very well indeed; temperate plants for the most part indifferently well. The latter are, however, taken care of at the mountain garden at Hakgala where the higher altitude (5,500 feet)

[2] John C. Willis, M.A. (Camb.), FL.S.

gives them a climate resembling that of western Washington and Oregon. The comparative coolness of tropical highlands is well illustrated by Nuwara Elliya, a resort near Hakgala, where in the hotels a grate fire is lighted nearly every evening throughout the year.

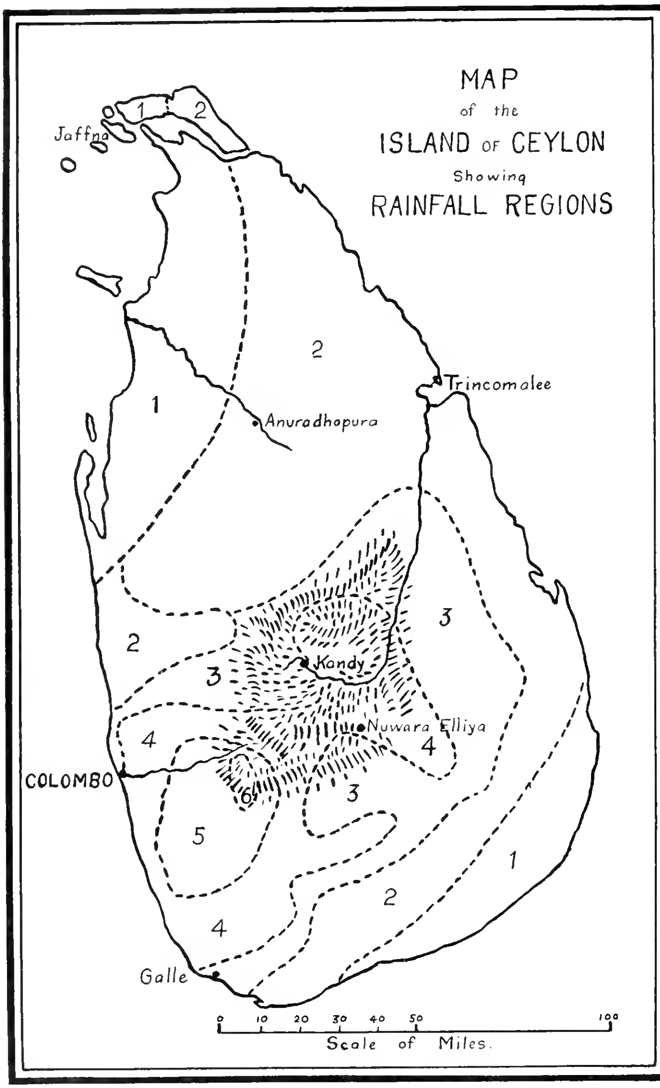

FIG. 2. MAP OF CEYLON. Peradeniya, not shown on the map, is about three miles east of Kandy in the central part of the island. The figures indicate annual rainfall as follows: 1, Under 50 in.; 2, 50 to 75 in.; 3, 75 to 100 in.; 4, 100 to 150 in.; 5, 150 to 200 in.; 6, 200 in. or more.

While an attempt is made to grow in the gardens all of the plants which are native to Ceylon, a great many plants from other parts of the world are also to be seen there. Indeed, the wealth of tropical beauty is here assembled. The flame tree of Madagascar, named from the brilliant color of the flowers, is a wondrous sight in March and April, the whole tree being a mass of red which hides the dark-green foliage. From India there is a tree, *Saraca indica*, with a profusion of brilliant orange-yellow flowers; and from tropical America various trees of the genus *Brownea*, especially interesting because of the graceful clusters of pendant young leaves. The leaves droop when young and tender, thus presenting very little surface for injury by the overhead sun. As they grow older a horizontal position is assumed and the red color is lost. It is supposed that the red coloring matter acts as a screen which protects the living substance of the young leaves just as the red glass in a photographer's dark-room window protects the sensitive plates from injury by light.

Among the most interesting plants are the bamboos, of which many different kinds are cultivated, some native, others imported from peninsular India or from other parts of Asia. Some interesting studies have been made at the gardens on the rate of growth of bamboo stems. These spring up almost as if by magic. To measure the growth from day to day no expensive auxanometer is needed, but only a tape measure and a coolie to climb an adjacent tree with the end of the tape. A day's growth is measured not in millimeters but in feet or inches. Bamboo stems are hollow, as are most grasses—for bamboos are but grasses—and are wonderfully strong considering the weight and the amount of material in them. Indeed, the principle of the hollow cylinder so well known to engineers was long understood by the Asiatics, who use bamboos for building purposes.

Of economic plants in the garden there seems almost no end. The balmy breezes of Ceylon may well be spice-laden. Ceylon cinnamon is known the world over. The various peppers, as black pepper, long pepper, betel pepper, are woody climbers. A handsome grove of nutmeg trees is planted near the entrance—the trees about seventy years old. On the ground under the trees may be found the seeds, *i. e.*, the nutmegs, and around them a covering, the aril of the botanist, which forms the spice known as mace. Clove trees may be seen also; it is the young flower buds of the tree which are dried to make the cloves of commerce. In the garden one may see the plants which furnish vanilla, citronella oil, tea, indigo, pineapple, ramie, sisal hemp and sago. Almost countless trees there are of economic importance. A few may be named, as those which furnish coffee, chocolate, cola, cocoanut, Brazil nut, camphor, rubber, gamboge and other tropical products.

In speaking of economic plants mention must be made of the experiment station which is really a part of the garden, although situated across the river. As a matter of fact nearly all the world lies across the river from the Peradeniya gardens, as these are situated in a bend of the stream which flows first north, then west, then south around the gardens. The experiment station was formerly a private estate bought by the gardens at a low price because it had been allowed to run down and the chocolate trees nearly all become diseased. Scientific methods of tending and care have been introduced and a model plantation developed. Here experiments are made with new agricultural crops and with new methods of treatment. The different species of trees furnishing rubber are being tried as well as improved varieties

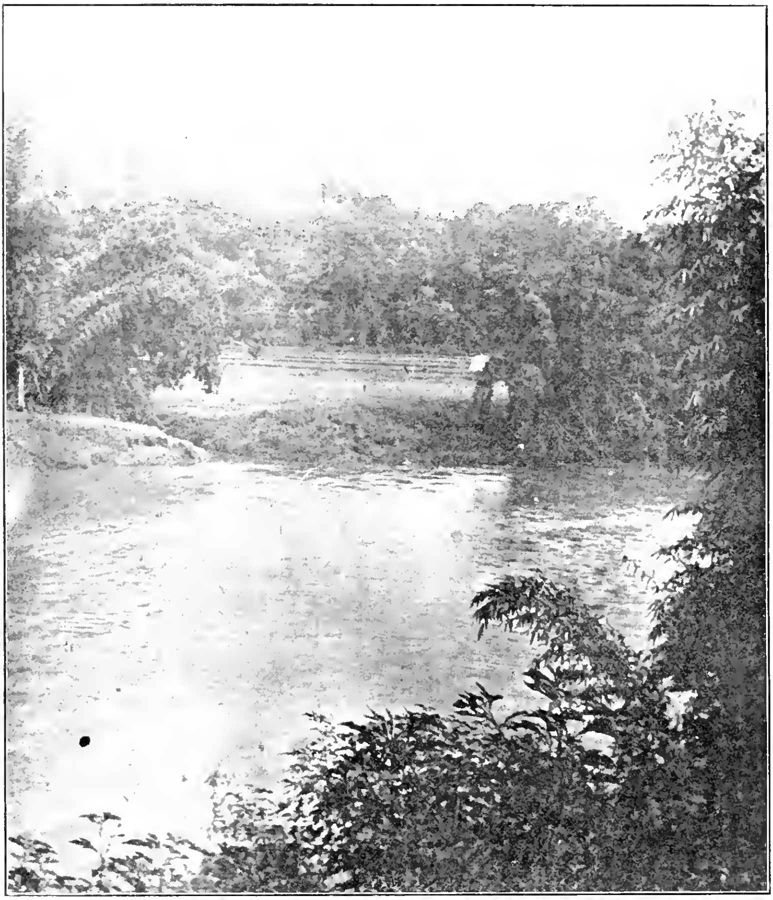

FIG. 3. BAMBOOS ALONG THE RIVER IN THE PERADENIYA GARDENS. In the clearing across the stream is a small rice field. From a photograph by the author.

of chocolate, cardomoms and other crops. Throughout Ceylon there is much general interest in scientific agriculture and the controller of the experiment station has the encouragement and moral support of the thinking population, both European and native. The daily newspapers at Colombo also give much attention to such matters and assume a sympathetic attitude toward government scientific work, in refreshing contrast to many of the newspapers in this country.

An attractive plot at Peradeniya is the Kitchen Garden, in which are assembled such "vegetables" as will grow in that hot, moist climate. Many of our common vegetables do well and can be had at all seasons, for example, beans, beets, peas, celery, lettuce and cress. Potatoes are generally small and poor. Sweet corn will grow in Ceylon, but has not thus far come into use. Of tropical vegetables various "yams" are much used, particularly by the natives. The word "yam" is applied to tubers and thickened roots of many different species of plants. Eggplants, different from ours in the temperate zone, are cultivated, also certain plants used, for "greens." Breadfruit trees produce the large heavy fruits of that name, but these would properly be classified among vegetables. Breadfruit is not much used by the British in Ceylon, who, in fact, eat chiefly the same things that they are accustomed to eat at home on their own tight little island.

Thus far we have been considering the attractions of the Peradeniya gardens to the casual visitor. To the botanist they are even more interesting. Every facility is offered by the director of the gardens for investigation by visiting men of science. There is a good herbarium in charge of competent curators and a working library of botanical books and periodicals. Good laboratory facilities are also offered. Although the laboratory for visitors is not fully equipped with physiological apparatus, there are the usual necessaries and it is easy to obtain all ordinary supplies at Kandy or Colombo. Native joiners, tinsmiths and metal-workers can be secured at very low rates to make articles needed. Photographic materials may be obtained at Kandy, only three miles away, and skilled photographers may be engaged to develop negatives or do other photographic work such as making lantern slides.

Opportunities for securing museum material are excellent. Collections of tropical woods properly named are prepared to order by dealers in Kandy. Plant material may be collected from the garden and preserved in formaldehyde or alcohol. Herbarium specimens from the garden can be collected and dried, but the botanist will need to remember that nothing short of the most thorough drying will suffice. It will also be necessary to use a liberal amount of naphthalene scattered through the dry specimens at all times. A native plant collector is detailed by the director of the gardens to assist visiting botanists in getting material from either the garden or the jungle. This man is well acquainted with nearly all of the species in the garden or growing in the vicinity and can usually tell the scientific name offhand, although sometimes he needs to refer to the herbarium. At the laboratory native assistants are provided who clean up apparatus and glassware and make themselves generally useful.

One of the most interesting things about Ceylon is the way in

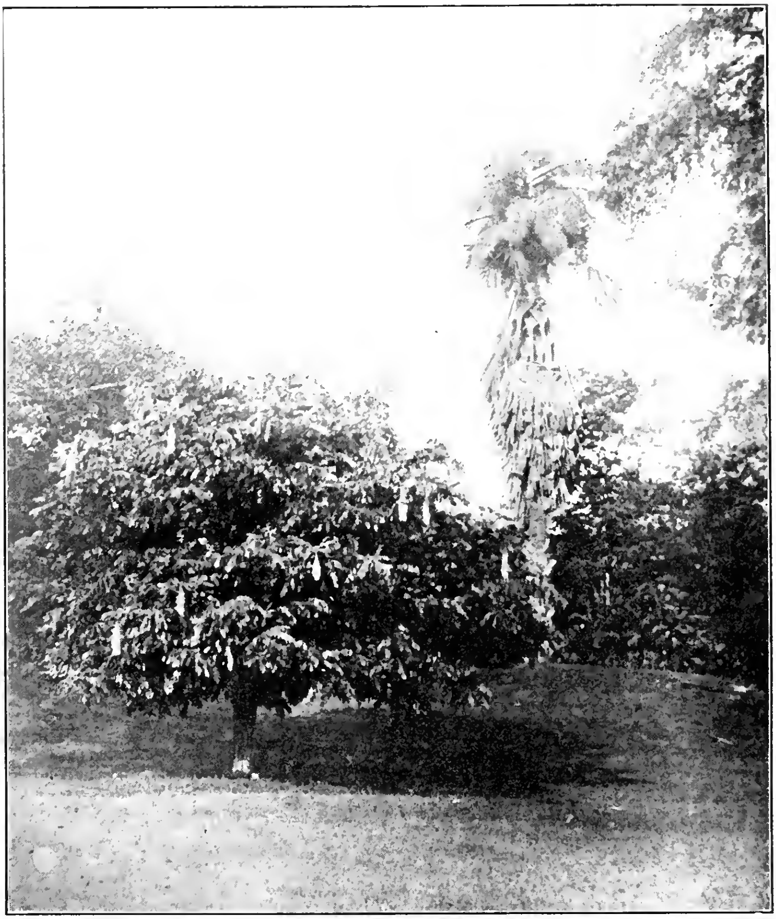

FIG. 4. *Brownea*, A TREE WITH YOUNG LEAVES HANGING LIMP AT THE ENDS OF THE BRANCHES. At the right a Talipot palm in blossom. From a photograph by the author.

which the jungle comes to the very door of civilization. In our own country we do not find "backwoods" close to cities and towns, but must travel a long way from Boston or New York to find the primeval forest. Ceylon, however, like other tropical countries, furnishes examples of jungle in close proximity to the large towns. Indeed, everywhere throughout the island the forest is easily reached. There is no half-way land in Ceylon. That which is needed for roads, gardens or fields is well cared for; other land grows up quickly to jungle. Old fields, abandoned a few years, soon become a dense thicket and later a forest. This is well seen at Anuradhapura, one of the ruined cities in the north central part of the island. Here, the government archeologists, as they find various parts of buildings such as columns and arches, set them up in place; but sometimes they neglect to clear out the trees for a sufficient distance and their "finds" once more become overturned by growing roots or the stems of gigantic climbers.

So, where jungle is the rule, and clearings have to be protected, it is natural that the botanical gardens should have a patch of jungle. This is situated in the experiment station grounds, but easily reached by the visitor. Here may be seen the native trees of the region in their natural condition and the visitor may get some idea of tropical luxuriance in the large number of species present on even a small tract of ground. It must be said, however, that a visit to this bit of jungle would be, to many visitors, a disappointment, for it is not filled with air plants hanging from the trees nor rendered impenetrable by interlacing stems of climbing plants. It is, however, much easier to travel through than the jungles at sea level in districts of great heat and humidity.

The botanist who is interested in ecology—the relation of the plant to its environment—is often on the lookout for field and roadside weeds. In temperate regions, particularly in the western United States, roadside weeds make a constant and striking feature of the landscape. This is not the case, as a rule, in the tropics. Indeed, there are not only rather few weeds, but few flowering herbs of any kind. The

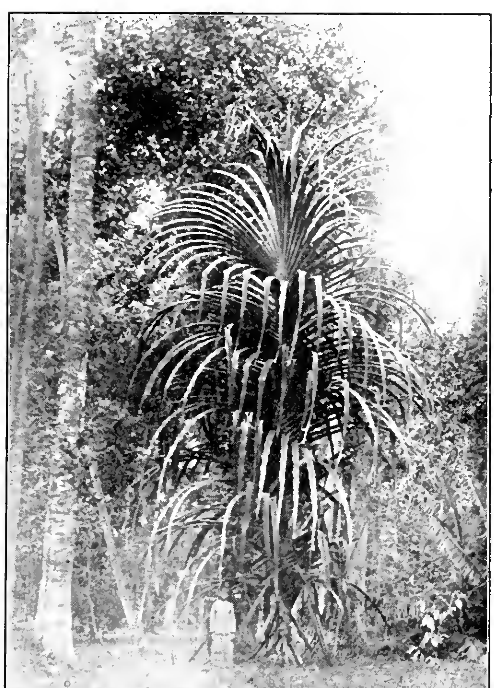

FIG. 5. A "SCREW PINE"; not a pine at all, but a monocotyledon of the genus *Pandanus*. From a photograph by the author.

tropics are a region of big things and the herbaceous plants make little impression on the visitor. At the Peradeniya garden, the writer noted a small area of perhaps half an acre that had been neglected for a time. Here, although there were many tree seedlings started, there was a fairly good patch of weeds—enough to make a lonely American feel quite at home. These weeds were chiefly *Lantanas* and some of our American composites, particularly the fleabane *Erigeron* and also *Conyza*.

It would be difficult to find elsewhere in the world an area the size of Ceylon, or even much larger, with so many different vegetation regions. The differences in these regions are brought about largely by

Fig. 6. Laboratory and Herbarium. At the far right is the office of the director. From a photograph by the author.

the winds which determine the distribution of rainfall and by altitude with consequent temperature changes. The wet weather comes with the rains from two different directions. The northeast monsoon commences in October and brings heavy rains throughout the higher parts of the island and in the lowland country of the northeast. A series of rains continues through November and December, with a rather light rainfall during January, February and March. In April the wind changes to southwest and there is more rain, with June especially wet. From then until October the rainfall is again lighter. It will be seen then, that in the highlands it is always moist, but that there are certain districts which have a rather pronounced dry season. The driest parts of the island are in the north and the south or northwest and southeast, in other words, in those parts placed as outlying districts at right angles to the directions of both monsoons.

The climate at Peradeniya is such that the botanist can live there in comfort and work regularly. It is a good place to begin the study of tropical plant life, as it is not extreme in either rainfall or temperature. From Peradeniya it is easy to reach the various parts of the island with their remarkably different floras. Traveling is not expensive and as English is the regular commercial language it is easy to get around.

Although the different plant formations of Ceylon are almost without number, yet a rough classification may be made as follows: (1) lowland evergreen rain forest; (2) upland evergreen rain forest; (3)

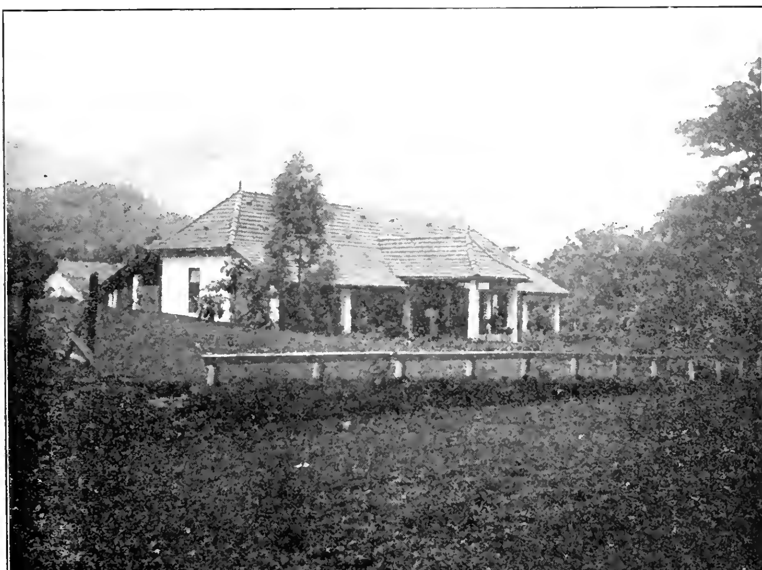

FIG. 7. GOVERNMENT REST HOUSE NEAR THE ENTRANCE TO THE GARDEN. From a photograph by the author.

mountain evergreen rain forest; (4) monsoon forest (half deciduous). There is no plain or prairie of any extent. Our first named formation is in the southwestern part of the island extending from Galle to Colombo and inland for twenty to fifty miles. Peradeniya is situated in the upland evergreen rain forest. Nuwara Elliya and Hakgala (about 6,000 feet altitude) may be taken as examples of our third region. These points are easily reached from Peradeniya by rail, the trip taking about half a day. Above these points the mountains rise 2,000 or 3,000 feet higher, but there is no true alpine vegetation anywhere in Ceylon. At Nuwara Elliya the general aspect of vegetation is much like that of temperate America or Europe. The trees are much

FIG. 8. A PORTION OF THE GARDEN, with formal beds and wide expanse of lawn arranged to please European tourists. From a photograph by Macmillan kindly furnished by the director.

stouter than those of lower altitudes and not so tall. In these mountain highlands in addition to forest there is a certain amount of "open country," the *patanas*. These are expanses of grassland on hillsides and rolling ground. The monsoon forest occurs in the drier regions of the island in the northwest and southeast. Here there are no very tall trees as compared with those of the rain forest and many of them are short and scrubby—very much branched after the manner of dry-country plants the world over. A considerable number are deciduous, losing their leaves in the hotter and drier months of spring to put them on again in the period of the monsoon or rain-bearing winds.

In the hot, moist lowlands of the southwest part of the island a typical strand flora may be seen. There are mangrove swamps and thickets of Nipa palm. It is in such very hot districts that rubber is grown and the cocoanut flourishes also. The drier regions have usually what would be a fair allowance of rain if in the temperate zone, but the tropical heat causes such rapid evaporation that the fifty inches of annual rainfall at Anuradhapura is not sufficient to grow crops without irrigation. Here then is a truly arid district. Farther north at Jaffna it is still drier, so that almost desert conditions prevail at least for a part of the year. As these dry regions can be visited easily at all times of year they make a very attractive feature of the island from the standpoint of the botanist. They are especially interesting to the American student familiar with the arid conditions of the west. In America all arid lands are practically treeless, but in Ceylon the forest is the natural plant formation even in dry areas.

With all of the different floras to be seen in the various parts of the island a botanist may get a good idea of the tropical world in a short time and with slight expense. The director of the gardens and his staff are anxious to have scientific visitors, not only botanists, but zoologists and geologists as well. Two rooms at the government Rest House (a kind of hotel) are reserved for scientific visitors and no charge is made for lodging, although, of course, table board must be paid for. The cost of living will be found to be not more than in other tropical countries with fewer advantages for study.

Ceylon has never attracted a great number of students, but a considerable amount of valuable work has been done there. Haeckel certainly obtained many of his philosophical ideas of the plant and animal worlds during his visit to the island. Modern science and philosophy owe much to the influence of Ceylon on his writings. But Haeckel's zoological collections were also valuable, and the collections of others at later times have added much to the world's store of knowledge in regard to tropical life. On the side of botany probably the name which is oftenest associated with Ceylon is that of the late H. Marshall Ward, who as a young man spent two years on the island studying the coffee disease. Although he worked out the etiology of the disease and the life history of the parasite, he was unable to devise a method of prevention. Henry Trimen, who was director of the gardens at Peradeniya for sixteen years, published the "Flora of Ceylon," which was completed by Sir Joseph Hooker in 1900, after the death of Trimen. It is interesting to note that Hooker had himself collected plants in Ceylon fifty-three years before. Of recent publications the work of Mr. Willis, the director, on a curious family of plants, the Podosto-

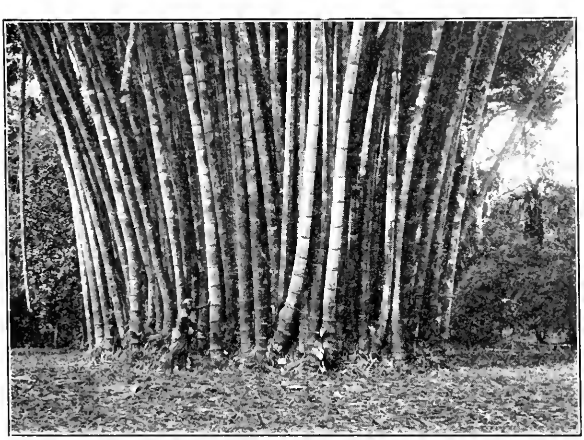

FIG. 9. GIANT BAMBOOS. Photograph by Macmillan kindly furnished by the director.

maceæ, is especially noteworthy. An exhaustive study of the trees of the ebony genus has been made by Mr. Herbert Wright. Mr. R. H. Lock has also done some remarkably good work in plant-breeding experiments which deserve special mention. Various students have worked on minor problems, with results which have been published in both European and American journals. In June, 1901, there was begun the publication of the *Annals of the Royal Botanic Gardens, Peradeniya*.[3] This publication is issued at irregular intervals at a nominal price. It contains contributions from the director and other members of the scientific staff of the gardens.

The West Indies and the Philippines will, no doubt, attract more students of botany from America than will Ceylon, but in a few years no one will claim to be a trained botanist unless he has had the advantages of study in some tropical laboratory. There is no tropical land which offers better opportunity than Ceylon for botanical study. Nor can one find any tropical country with a more intelligent and progressive population, finer cities or more beautiful scenery.

One will naturally make comparisons between botanical opportunity at Peradeniya and at Buitenzorg,[4] in Java. It may be said that the establishment at Buitenzorg is much older and better provided with funds, but that Peradeniya is a more comfortable place to live, that traveling is much less complicated and communication more easy because of the use of English by the natives. In Java one must learn Malay in order to communicate with servants. On account of the very moist climate, Buitenzorg presents a more luxuriant vegetation, but this very great moisture makes work harder, and in the afternoons it is practically impossible to do any kind of study in the garden on account of rain. To many people the large number of visitors in the Buitenzorg gardens seems a detriment. The place is too much "civilized." At Peradeniya, on the other hand, the number of casual visitors is rather small, and they do not embarrass the student by their presence or their questions. It will be seen that it is impossible to say which of the two places will be better for the student. Something depends on the kind of work he wishes to do and very much depends on his own temperament. In fact, both gardens should be visited, and the length of time spent in each be determined by conditions as they arise.

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[3] Students interested in knowing more concerning the opportunities for research at Peradeniya should consult the first number of the *Annals* in which these opportunities are fully set forth. An excellent account of the island of Ceylon with a statement of its resources is given in the "World's Fair Handbook of Ceylon," prepared for the St. Louis Exposition.

[4] See an article by the present writer in this magazine for November, 1905.

THE PREHISTORIC ABORIGINES OF MINNESOTA AND THEIR MIGRATIONS[1]

By N. H. WINCHELL
MINNEAPOLIS, MINN.

It would have been considered an act of great temerity twenty-five or thirty years ago to enter upon an investigation of the Indians of Minnesota in prehistoric time. But, thanks to the rapid progress that has been made in aboriginal research in North America, chiefly under the guidance of the late J. W. Powell and his associates in the Bureau of Ethnology at Washington, it is now necessary only to apply to Minnesota some of the great truths that have been established as to the Indians at large, and to designate under those principles what Indian stocks and tribes have inhabited the state in some of the centuries that preceded the advent of the whites.

In order to clear the field at the outset by the removal of any obstacles that we may have inherited from earlier conceptions of the aborigines, it will be well to repeat some of the important results that have been reached within recent years, viz.:

1. The origin of the ancestors of the Indians was so remote that nothing yet discovered indicates its date or the source from which they came.

2. There are between fifty and sixty Indian stock languages, some of which are as distantly related as the languages of the various Aryan nations, but most of which are as distinct as the English from the Semitic.

3. This shows that the aborigines, if they came at all to America, must have come from a great many directions, or that their coming was so remote that they must have developed these differences amongst themselves by long periods of isolated residence in North America.

4. The Indian stock languages can not be connected, at least have not been connected as yet, with any convincing bond of relationship, with either European or Asiatic languages. The Eskimo are here not included, as that stock ranges from Greenland through North America into Siberia.

5. The aborigines, therefore, are indigenous to the soil of America in the same sense that the Mongolian and Caucasian are indigenous in the lands of the Eastern continent.

6. The "moundbuilders," that fabulous race of Squier and Davis,

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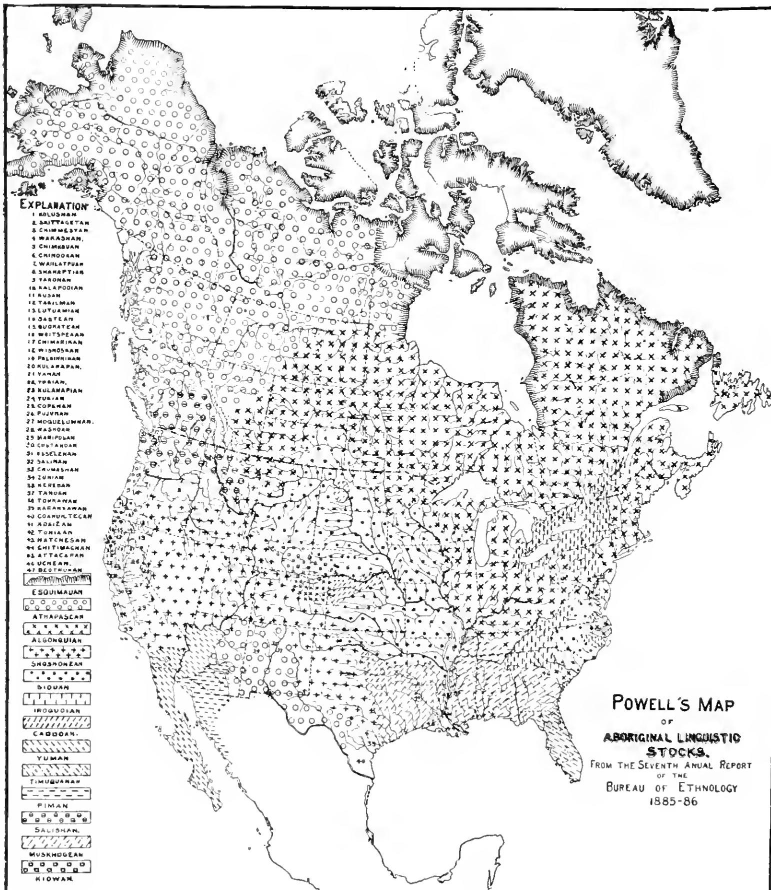
[1] An address before the Minnesota Historical Society, February 9, 1907.

were the ancestors of some of the Indian tribes of history. What those tribes were is gradually being unraveled.

7. The greatest number of the aboriginal language stocks were located along the Pacific coast, say in California, and along the Atlantic and Gulf coasts in the southeast; the interior of the continent being occupied thinly by only three or four stock tongues, these being Athapascan, Shoshonean, Algonquian and Siouan. The Kiowa, who



also were in this central area, are thought by some to be an independent stock, but by others related to the Comanches, and hence may, for our present purpose, be classed with the Comanches in the Shoshonean family. The Pawnee, or Caddoan, family was feebly represented in the interior of the continent aside from their main habitat at the gulf coast and in Texas; but the Iroquois shared with the other wide-spread families in the possession of the interior. These, however, appear to have linguistic alliances with the Cherokees and more distantly with the

Siouan stock. Hence again, for the purpose of the present discussion, the Iroquois may be considered with the Siouan family.

Of these four great family stocks it will be the purpose of this paper to deal mainly with the last two mentioned, *i. e.*, the Algonquian and the Siouan.

In the Algonquian family are embraced the following tribes, as stated by J. W. Powell, as well as several other small tribes that dominated the north Atlantic coast; the arrangement here is that of D. G. Brinton in the previsional order of their linguistic affinities, the oldest and perhaps the parent tongue, the Kilistino, heading the list:

- Cree (Kilistino)
- Old Algonkin
- Montagnais
    - Ojibwa
    - Ottawa
    - Pottawotomi
    - Miami
    - Illinois
    - Pea
    - Piankishaw
    - Kaskaskia
    - Menominee
    - Sac
    - Fox
    - Kikapoo
        - Micmac
        - Etchemin
        - Abnaki
            - Delaware
            - Shawnee
            - Mohecan
            - Nanticoke
                - Gros Ventres (of the Plains)[2]
                - Sheyenne

To these may be added the Arapahoe, associates of the Sheyenne in Wyoming, not mentioned by Brinton. These show, according to Krœber, certain characteristics that mark them as differing from the other Algonquians, both in speech and in tribal organization. There is no history or tradition of their origin. They have no clans nor totemic divisions, whereas these are marked features of the most of the Algonquian stock. Certain more elemental characteristics of their dialect, and the certainty of their having long preceded the Sheyenne in their present habitats, seem to warrant the assumption that they are more primitive than even the Kilistino.

The area formerly occupied by the Algonquian family was more extensive than that of any other linguistic stock of North America, their territory reaching from Labrador to the Rocky Mountains, and from Churchill River of Hudson Bay as far south at least as Pamlico Sound of North Carolina. (Powell.)

[2] There were two tribes of Gros Ventres, so named by the French, distinguished as Gros Ventres of the Missouri, a tribe of the Siouan tongue, and Gros Ventres of the Plains, who were Algonquian.

The Dakotan, or Siouan, family comprised the following Indian nations, arranged approximately in order of apparent derivation:

Biloxi
Tutelo
Waccon
Catawba
    Huron Iroquois?
    Cherokee?
        Winnebago
        Omaha
        Osage
        Issati
        Mandan
        Missouri
            Dakota
            Iowa
            Ottoe
            Hidatsa (and Crows)

having numerous subtribes, viz., Santee, Sisseton, Wahpeton, Yankton, Yanktonai, Teton, Blackfeet, Minneconjou, Ogalala, Ponka, Assiniboin, Akansea, Kansa and others.

The position above assigned to the Cherokee and Iroquois is conjectural, but is based on the statements of some authorities. Mr. Horatio Hale has sufficiently established the connection between the tongues of the Cherokee and the Iroquois, and Mr. Mooney has shown the relation between the Cherokee and the primitive tribes of the tongue in South Carolina. It may be that the alliance of the Iroquois with the Dakotan stock is so feeble that the two should be considered as separate stocks. But, for reasons that will appear, the Cherokee (Tselaki), the ancient Alligewi, seem to have had an ancestry which was cognate with that of the Dakota. It will be shown that they both moved from their pristine seat on the Atlantic coast in the Carolinas, where some archaic remnants of both tongues still continued in early American history.

The country occupied by the great Dakota stock, aside from the small tribes that remained near the Atlantic, was, in general, the "interior continental basin" so far as it lay west of the Mississippi River and east of the Rocky Mountains, with a broad tongue that extended into Canada so as to take in some of the waters that reach Hudson Bay, west of Lake Winnipeg. It covered the Missouri Valley except in its utmost upper reaches in the region of the Yellowstone Park, which belonged to the Shoshonean stock, and excepting also the valley of the Platte. It extended eastward in a narrow tongue, across the Mississippi, through southern Wisconsin to Lake Michigan, an anomalous geographic exception, the important significance of which will be referred to later. As to Minnesota, it was divided between the Algonquian and the Dakota stocks, the larger part being in possession of the Dakota. The Kilistino, an Algonquian tribe, were in the north and northeast, in the wooded region north of Lake Superior. Their dominion included the boundary waters not farther west than Rainy Lake, but continued unbroken to Hudson Bay.[3]

A few other general considerations ought to be stated at this point in order to prepare for the discussion of the topic in hand. These are:

1. During the prevalence of the last ice-epoch the state of Minnesota was covered with ice, and all previous inhabitants, whether fauna or flora, were driven southward to more congenial climes.

2. This condition ended between seven and eight thousand years ago. It is not necessary here to rehearse the investigations on which that result is based.

3. Between the ice-fields and the habitable portions of the continent lying to the south was a belt of country, the width of which varied according to the longitude and according to the topography, which was uninhabitable by reason of the severity of the climate. This uninhabitable belt may be compared to a belt in northeastern and northern Canada at the present time which is uninhabitable for the same reason. It was wider, however, than the northern Canadian belt, and less ameliorated along the banks of the rivers. Their waters drained from the northern ice fields, whereas the Canadian rivers carry waters from southern and more temperate latitudes. But like the Canadian belt it was wider toward the west. The ice-margin and the accompanying severity of climate crossed the country from southeast to northwest. The prehistoric isothermals, same as the present, passed northwestwardly.

4. Hence the habitable portions of the United States, until seven or eight thousand years ago when the ice began its retreat, were along the Atlantic seaboard south of New Jersey, a belt along the coast of the Gulf of Mexico, a large interior area without ascertainable limits, and the Pacific coast west of the Sierra Nevada.

5. So far as Minnesota is concerned, and the same is true of much of the northern United States, it seems to be necessary, therefore, to confine all investigation of aboriginal migration to an antiquity not greater than seven or eight thousand years.

6. For Minnesota it is necessary to make a still further restriction, for it was the ice-margin itself that retired seven or eight thousand

[3] Powell's map of linguistic stocks accompanying the seventh annual report of the Bureau of Ethnology, 1885–6, is quite incorrect for Minnesota. It gives by far too much area to the Algonquian. The boundary as shown by his map would be more applicable in the eighteenth century, after the inroads of the Ojibwa upon the Dakota had won a large part of the state. As it should be drawn from the earliest known habitats of the aborigines, it should start from the St. Croix River not far from the eastern side of Pine County, run thence northwardly to near the east end of Rainy Lake, thence northward and northwestward so as to leave Lake of the Woods to the Assiniboin, but to the southward of Lake Winnipeg and thence northwestwardly indefinitely to the valley of the Saskatchewan.

years ago from the vicinity of the falls of St. Anthony. It required, maybe, two thousand years more for the passage over the state of that uninhabitable belt already mentioned.

7. The people along the gulf coast and on the ocean shores would not have been quick to follow up the retiring cold of a glacial winter. They would not readily leave the warm lowlands, where food was abundant, to penetrate the wastes of a country that was still swept by cold winds and whose wide-spreading waters were chilled by the dissolution of the northern ice.

8. The occurrence, however, of an opportunity for migration was equivalent to the creation of an impulse, and after a time the southern tribes moved into the regenerated new country.

It is the purpose of this paper to give a glimpse of some of the movements of this migration, and to show how it affected Minnesota. The time within which these migrations occurred, for reasons already stated, can not therefore exceed five or six thousand years.

It will be reasonable to assume that wherever the chance for hopeful migration first presented itself there the first movement took place. Some weaker tribe was expelled by war, or, the people being crowded, some tribe sought more room and better quarters to expand in. This change must have begun in the southwest, perhaps no further south than Utah or Colorado, or perhaps some tribe of Mexico began the great migration. The same impulse toward northward migration was felt all along the gulf coast and on the Atlantic seaboard. Sometimes whole tribes abandoned their ancient seats and sometimes only a discontented portion of a tribe parted from their kindred. There must have been many conflicts and counter migrations and movements in all directions; but those who started first probably continued to move in the van as they were again pressed by those in the rear.

When there came finally a condition comparatively fixed, it must be allowed that the tribes had settled where their environment was best suited to their needs, subject, of course, to the dominance of more powerful tribes. It may be reasonably accepted that on attaining a condition of comparative quiet, the geographical situation of the linguistic stocks was approximately as represented on the linguistic map of Powell, barring, of course, such later changes of habitat as can be shown to have taken place either within historic time or by consistent application of tradition. A general sketch of the Powell linguistic map has already been given.

It is now necessary to examine it a little more closely and to note some of the more remarkable features. It is a most notable fact that the southern parts of the United States are thickly dotted over with small areas that denote the locations of numerous distinct aboriginal stocks, while the broad interior is occupied by a few widely spread stocks that were, as is known, thinly dispersed along the river courses and ranged in pursuit of game or of their enemies occasionally over the plains. The Athabascan stock, now occupying the interior of Alaska and of northern Canada, may be presumed to have been the first, or among the first, to leave their pristine seats. But they must have left a considerable number of their friends at home, since they still subsist in a large tract in eastern Arizona, western New Mexico and southwestern Texas, under the names of Apache and Navajo, with their subdivisions. The Shoshonean family may not have moved far from their pristine home, at least seem not to have entirely abandoned it, since the Shoshonean area still lies contiguous to the Pacific coast in southern California. They apparently simply improved the opportunity of expansion, and latterly perhaps dispossessed some weaker tribes. Still, it is quite possible that the Shoshonean people were powerful and spread over a wide interior area from which they have never departed even during the prevalence of the glacial climates of the north.

The two great Indian families, however, in which we are most interested are the Algonquian and the Siouan. Let us notice the contrasts in their distribution. The Algonquian spreads over the northeastern part of the United States and Canada, with a small root lingering adjoining the Shoshonean in Colorado, but has no representative on the southeast Atlantic coast. It is true that according to the map the Algonquian stock extends as far south on the Atlantic seaboard as North Carolina, but this southward expansion there is of later date and can be excluded from the discussion. Indeed, the whole Delaware confederacy, covering the Algonquian areas in New Jersey, New York, and some portions of New England as well as all of that in the states of Kentucky, West Virginia, Ohio, Indiana and the most of Illinois, can likewise be excluded, since, as will appear, their acquisition of those areas is of comparatively recent date. It appears, therefore, if the Algonquian stock was governed in post-glacial time by the forces which have been mentioned, that that people started from the southwestern country, spread over the interior plains, and preempted the timbered regions of Canada and the northern United States. It hence follows that the northern part of Minnesota, Wisconsin and Michigan, and the most of New England were the first settled habitats, in the United States, of the Algonquian people. Prior to the Dakotan incursion, the Algonquian probably controlled areas farther south, especially in Minnesota, while the mainly uninhabited interior, *i. e.,* the plains of the Missouri and of the upper Mississippi, were the fields over which for a long period of time all the surrounding nations sent war parties and hunters, but did not venture to make permanent settlements.

Now compare with this the distribution of the Siouan stock. It has two small areas on the Atlantic seaboard contiguous to similar areas of the Iroquois, but its main area is west of the Mississippi, embracing the wide plains over which roamed the buffalo. These areas are separated by the states of West Virginia, Kentucky, Ohio, Indiana, Illinois and Michigan, where now reside the Algonquian, or at least where they were found by the Europeans when they made acquaintance with the region. Guided by the same principles, we may infer reasonably that, on the amelioration of the glacial climate, the Siouan family, residing wholly on the southeastern Atlantic seaboard, migrated toward the north and west, crossing the mountains that bound them in, and sought the plains on the west. With the vicissitudes of war and the lapse of thousands of years, those who remained on the east side of the Alleghany Mountains were permanently separated from those who migrated, and the western tribes expanded rapidly over the western plains of the Missouri, becoming powerful and a scourge to their neighbors, "the Iroquois of the West," as they have been termed not inaptly.

We can infer, therefore, that these two stocks, the Algonquian and the Siouan, moving, one from the southwest and the other from the southeast toward the Mississippi Valley, early came into collision, and that in the main the Mississippi River at first constituted the boundary line separating their domains. This early hostility became a hereditary war, and on the side of the Siouan stock the Iroquois also participated. I do not know of any record, and of but one tradition, of war between the Iroquois stock and the Siouan stock west of the Alleghanies, but both these stocks maintained bitter and hereditary war against the Algonquian. The prehistoric Siouan people were neighbors in the Carolinas of the prehistoric Iroquois, and the two people more or less allied in language and having similar customs and the same opportunities for northward migration probably moved about simultaneously, both tribes crossing the mountains into the country where the waters flowed in the western direction, the Iroquois to the north of the Sioux.

It is a remarkable fact that, with the exception of the earthworks of the gulf coast, these two stocks are the only ones that have been found to have had a general custom of constructing earth mounds and embankments.[4] These common resemblances, regardless of any

[4] The mounds that are common in southern Michigan and along the Lake Huron shore northward from Detroit, as well as those in northern Ohio and western New York are attributable to the Iroquois or to some of their kindred tribes, viz: the Hurons, Eries and Neutrals. The Iroquois dominion extended to the north shore of lake Huron even in historic time. An old Dutch map of 1690 (?) published by Van der Aa has "Iroquoysen" in the northern part of Wisconsin. Indeed there is good reason for believing that the Iroquoian and Siouan stocks at this time possessed the whole country east of the Mississippi River and south of the Great Lakes to northern Georgia, constituting together the great Ohio dynasty of the mound-builders. The true earth mounds of northern Wisconsin are probably later than this period. Mr. Geo. A. West says

linguistic affinity, are sufficient to point to an early common origin. If the Algonquian stock in any of its tribes is found to have constructed mounds, such as those characteristic of the Ohio mound-builders, it seems to have been only exceptional or sporadic, or may be attributed to adoption from their neighbors belonging either to the Iroquois or the Siouan stock. I know that Dr. Thomas has shown the great probability that the Shawnees, an Algonquian tribe, were the authors of certain mounds in western Tennessee and contiguous territory farther southeast, and specially of those that cover the characteristic stone-box graves. Admitting that, it is still true that the Shawnees have not been shown to have been mound builders in a wide sense, and that, carrying the habit of subsurface burial with them when they left their kindred and migrated into southern Illinois and western Tennessee, they might easily have adopted the custom of their mound-building new neighbors and covered their box graves with earth mounds. But, without admitting at present that the Shawnees constructed the mounds that cover the stone-box graves, it seems to be reasonable to refer those mounds to the predecessors of the Shawnees, viz.: the Osage and perhaps the Omaha, who belong to the Dakotan stock, and who have a tradition, which is confirmed by other traditions, that they once lived east of the Mississippi in that very region. With this understanding, it is, I repeat, a remarkable fact that, aside from the Muskogean earthworks of the gulf coast, which have distinctive characters, only the Dakotan and Iroquois stocks can be shown either by history or tradition to have been characteristic mound-builders.

It is due to the research of the late J. V. Brower that the Dakota tribes of Minnesota have been proved to belong to the so-called mound-builder dynasty. But the mound-builder domain was, *par excellence,* in the Ohio Valley and southward into Kentucky, Tennessee and northern Georgia and eastward into West Virginia. There is also a remarkable series of effigy mounds in central and southern Wisconsin which extended across the Mississippi into Minnesota and Iowa. With slight exceptions the typical mound-builder area was occupied, as shown by Powell's map, at the coming of the whites, by non-mound-building people; while the great body of the mound-builders, represented by the Siouan stock, were on the west side of the Mississippi, in a region which had been passed by, or ignored, by the early migrating stocks.

As between a prairie and a forested country it is plain that the forested area would be chosen first by the aborigines. Aside from the

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that the Sioux at different periods occupied the greater part of what is now Wisconsin. Mounds have been described by John T. Short ("North Americans of Antiquity," p. 30) in the valley of the Columbia River, south from Olympia, but these have since been ascribed to natural causes by Messrs. Rogers and Upham (*Am. Geol.,* Vol. XI., p. 293 and Vol. XXXIV., p. 203).

shelter afforded by the timber, the forests yield food more easily captured, as well as material for his habitation and for his implements of war and the household; while the annual devastation by fire rendered the prairie not only uninhabitable, but actually dangerous. It is certain, therefore, that the occupancy of the prairies has been, in general, the latest step in the establishment of the dominion of the aboriginal tribes. In other words, it is only a late migration which has brought the Siouan tribes into the plains of the Missouri and of the upper Mississippi, and with this fact agrees all the evidence that can be found that bears on it, whether from a study of the people themselves, of the mounds, or of their traditions.

It will be anticipated, from what has been said thus far, that the original mound-builder dynasty in the Ohio Valley was destroyed by an incursion of hostile people belonging to the Algonquian stock. It will be the burden of the rest of this paper to establish that great prehistoric event, and to show what effect it had on Minnesota.

Dr. Cyrus Thomas is to be accredited with the most thorough investigation of the aboriginal earthworks of the country. Under the direction of the Bureau of Ethnology he has established some important generalizations and has traced out some of the movements of the tribes that were concerned in the war which resulted in the expulsion of the original mound-builders from Ohio and the contiguous regions. Suffice it to say here that he considers that the evidence shows a movement, at least an extension, of the earliest mound-builders from the region of eastern Iowa, southeastern Minnesota, and southwestern Wisconsin, across Illinois and Indiana into Ohio. He shows that these people were driven out toward the east and southeast. He traces this retreat, which may have required several hundred years for its completion, with the most patient and convincing research, and arrives at the conclusion that when the whites came upon the scene the defeated and expelled people were known as Cherokee, living in western North Carolina and eastern Tennessee, and were still building mounds. The last statement is abundantly verified even by historic documents. De Soto met them in his trip across the cis-Mississippi region, and his chroniclers describe the mounds which they saw. Some of the mounds built by the Cherokee in their new home contain articles of European manufacture.

But this line of persistent aggression from the northwest to the southeast, resulting in the expulsion of the Cherokee from the upper part of the Ohio Valley, was not the whole of the great war, though it is the only part that has been established by evidence like that adduced by Dr. Thomas. It can hardly be questioned that such an incursion would have had a disastrous effect on the mound-builders of the whole Ohio Valley, and that they were all driven out at the same time and by the same hostile force.

It is necessary now to rely on tradition, and on the preliminary considerations already presented, to show what became of the rest of the moundbuilders of the Ohio dynasty. It is apropos, however, to remark that the whole of the moundbuilding people could not have escaped by the route traced out by Thomas up the valley of the Kanawha River. By far the larger part of them had a habitat further south and further west, and the most probable line of retreat for them was down the Ohio Valley.

There are many traditions that relate to the migrations of the native tribes within the United States. I will call your attention to but two of them. These relate to the great movements that are here discussed, but they are confirmed by several others that supply contributory details, and when taken all together their force amounts almost to as great a body of evidence as if the events were a matter of history.

These two traditions have been accepted by all archeologists as trustworthy testimony, as far as the Indians could communicate a history of past events. The only differences of opinion that have appeared pertain to the interpretation and application of the traditions themselves.

One of these two traditions recounts the hostile incursion of the Lenni-Lenape, an Algonquian tribe or group of tribes, into the region west of the Alleghany Mountains, their conflict with the "Tselaki," a word which has been corrupted into Cherokee, and with the Allegewi, a word which is perpetuated in the term Alleghany, and their final settlement, under the name Delaware, in the eastern part of Pennsylvania and in New Jersey, together with some further migrations toward the east. The other relates to the migration of some of the Siouan tribes down the Ohio River and their going "up stream" and "down stream" on the Mississippi on reaching the mouth of the Ohio. I do not know that any one has called in question the essential parts of this tradition.

John Heckewelder, a Moravian missionary with the Delaware or Lenni-Lenape in Pennsylvania, gave the first printed account of the hostile incursion of the Lenni-Lenape against the Ohio mound builders. It is published in Vol. XII. of the memoirs of the Historical Society of Pennsylvania, in 1818. He took it from the relation of the intelligent Indians. With some abbreviation it is as follows:

"The Lenni-Lenape (according to traditions handed down to them by their ancestors) resided many hundred years ago in a very distant country in the western part of the American continent." For some reason they determined on migrating to the eastward, and accordingly set out together in a body. After a very long journey, and with many long stops on the way, they at length arrived on the "Namaesi-sipu," which by Mr. Heckewelder is translated "Mississippi, or River of

Fish," when they fell in with the Mengwe, who had likewise emigrated from a distant country, and had struck upon this river somewhat higher up. [The Mengwe were the Iroquois.] "Their object was the same with that of the Delawares: they were proceeding on to the eastward until they should find a country that pleased them. The spies which the Lenape had sent forward for the purpose of reconnoitering had long before their arrival discovered that the country east of the Mississippi was inhabited by a very powerful nation, who had many large towns built on the great rivers flowing through their land." These people called themselves Tallegewi or Allegewi. [According to later research this is the aboriginal rendering of the name "Tselaki" which De Soto gives to the Cherokee when he encountered them at a much later date farther south.]

Many wonderful things are told of this famous people. They are said to have been remarkably tall and stout, and there is a tradition that there were giants among them, people of much larger size than the tallest of the Lenape. It is related that they had built for themselves regular fortifications or entrenchments, whence they would sally out, but were generally repulsed. I have seen many of the fortifications said to have been built by them.

When the Lenape arrived on the banks of the Mississippi, they sent a message to the Allegewi to request permission to settle themselves in their neighborhood. This was refused them, but they obtained leave to pass through the country and seek a settlement farther to the eastward. They accordingly began to cross the Namaesi-sipu, when the Allegewi, seeing that their numbers were so very great, and in fact consisted of many thousands, made a furious attack on those who had crossed, threatening them all with destruction if they dared to persist in coming over to their side of the river. Fired at the treachery of these people and the great loss of men they had sustained, and besides not being prepared for a conflict, the Lenape consulted on what was to be done, whether to retreat in the best manner they could, or try their strength and let the enemy see that they were not cowards, but men, and too highminded to suffer themselves to be driven off before they had made trial of their strength and were convinced that the enemy was too powerful for them. The Mengwe, who had hitherto been satisfied with being spectators from a distance, offered to join them on condition that after conquering the country they should be entitled to share it with them. Their proposal was accepted, and the resolution was taken by the two nations to conquer or die.

Having thus united their forces, the Lenape and the Mengwe declared war against the Allegewi, and great battles were fought in which many warriors fell on both sides. The enemy fortified their larger towns, and erected fortifications, especially on large rivers and near lakes, where they were successively attacked and sometimes stormed by the allies. An engagement took place in which hundreds fell, who were afterward buried in holes, or laid together in heaps, and covered with earth. No quarter was given, so that the Allegewi at last finding that their destruction was inevitable if they persisted in their obstinacy, abandoned the country to their conquerors, and fled down the Mississippi River, whence they never returned. [Mr. Heckewelder gives some further details of the war, the result of which was that the Mengwe, or Iroquois, chose the country round the Great Lakes and the St. Lawrence River, and the Lenape settled farther south. After a time the Lenape moved farther east, and even to the sea.]

They say, however, that the whole of their nation did not reach this country; that many remained behind in order to aid and assist that great body of their people which had not crossed the Namaesi-sipu, but had retreated into the interior of the country on the other side on being informed of the reception which those who had crossed had met with, and probably thinking that they had all been killed by the enemy.

The tradition continues further, but is not essential to this inquiry except so far as it shows that the Lenape finally spread themselves into the eastern states, establishing new tribes, and into Virginia and Maryland, and states that these younger offshoots recognized their relationship by calling the Lenape their grandfathers, this proving a confirmation of the recentness of the southern Algonquian tribes.

Several important conclusions can be drawn from this tradition, should it be accepted as mainly based on fact. First of all it should, however, be remarked that the well-known Iroquois were never on the Mississippi River in any such war. Either some other river must be understood, or it must be presumed that the alliance with the Mengwe was an event of the later part of the war, and that in the relation it was not sufficiently indicated that the Lenape waged alone a long war of aggression against the Allegewi and drove them from a large part of their domain before the Iroquois tendered their services. The latter alternative is the more probable, since the Huron-Iroquois have only been known as an eastern nation, and since the legend would not so many times mention the Mississippi by name unless there was a grounded conviction in the mind of the narrator, which seemed not likely to be misunderstood, that the Mississippi was crossed by the Lenape.[5]

We may reasonably infer from this tradition, in the light of what we know from a study of the mounds and their characteristic distribution:

1. That the Lenape struck the then mound-builders in southeastern Minnesota and northeastern Iowa, in the region of the effigy mounds, these earthworks being admitted by all to be older than the great mass of the small tumuli of the Mississippi Valley.

2. There was a period of interruption in the war during which the aggressors rested and dwelt peacefully in the land which they had won.

3. On the resumption of the war not all of the Lenape participated, but some remained on the banks of the Mississippi. These may have become known later as the Kaskaskia, Kikapoo, Illinois, Miami, and further south, the Shawnee. It is distinctly stated that a large body

[5] Since this was written the old Dutch map of unknown date has been discovered showing "Iroquoysen" in the region of northern Wisconsin, and if dependence can be placed on that map the Iroquois (*i. e.*, the Hurons or other tribe of that stock) may have united with the Lenape on the east bank of the Mississippi in Wisconsin, according to the statement of the tradition.

remained, some "beyond the Mississippi," and others "where they left them on this side of the river," in the words of the missionary.

Mr. G. E. Squier (1848) later examined this tradition. He fell into the possession of a series of original manuscripts, "through the hands of the executors of the lamented Nicollet," among which was one by Professor C. S. Rafinesque, which was entitled the "Walum Olum," a record preserved on painted sticks, translated by Rafinesque from the original symbols and the Algonquian words written along with them by some interpreter who understood both.

Omitting those portions relating to the creation of the earth, to the deluge and the running off of the waters which show the effects of contact with the European missionaries, I will briefly mention the views of Mr. Squier and the points of coincidence or divergence from the rendition of Heckewelder. Mr. Squier says:

> The details of the migrations here recounted, particularly so far as they relate to the passage of the Mississippi and the subsequent contest with the Tallegwi or Allegwi, and the final expulsion of the latter, coincide generally with those given by various authors, and well known to have existed among the Delawares.

According to the Rafinesque rendition, as given by Squier, there were two great wars. The first was after a migration from the north to the south, attended by a contest with a people denominated Snakes, who were driven toward the east, and the Lenape remained for a time in their land, and multiplied and spread toward the south to a beautiful land which is also called "big-fir" land. In consequence of drouth they move again south into the buffalo land. Here they dwell for some time, when finally their chief leads them toward the rising sun and they arrive at the "Messissipee" or the Great River, the Mississippi, when they stop; but they soon descry the Tallegwi and make war upon them. This war continues through the lives of several chiefs, but ends by the expulsion of the Tallegwi who were driven southward, the victors taking possession of the land where they resided and flourished under a long succession of chiefs. Here they built towns and planted corn, and here, after the expulsion of the Allegewi, is the first mention of the Iroquois, and instead of being their allies they are enemies. They are called Talamatan and Mengwe.

Then commences, apparently, a repetition of the same narration in different words and more in detail, a characteristic feature of many ancient records and legends. In this account, the Lenape departed from a northland, where it was cold and froze and stormed, and they went south to possess milder lands abounding in game. They hunted in all directions and came to the Snake land, whose inhabitants fled in great fear.[6] The pursuers passed over a hard, stony and frozen "sea," and came to the land of fir trees, which they called "Shinaki."

After the lapse of an indefinite time, during which they remained in the land of firs and came into hostile contact with several of the surrounding people, among whom are Chiconapi, Makatopi, Akonapi and Assinapi, they passed "over a hollow mountain" and found food in the plains of the buffalo land, along a yellow river, where they built towns and raised corn, and remained for a long time, under a number of different chiefs.

Becoming dissatisfied, they "longed for the rich east-land," and on moving in that direction they came into conflict with the Tallegewi. "The Talamatan and the Nitilowan all go united" (to the war); and fell upon and slew great numbers of the Tallegewi. Sometimes they were repulsed by the Tallegewi, but finally all their towns were captured and they fled to the south, and the Talamatan (Hurons?) settled north of the lakes, the Lenape on the south side, *i. e.,* in the land of the Tallegewi.

The rest of the chronicle pertains to later movements in Pennsylvania and New Jersey and their early dealings with the English.

According to both these renditions, all those events preceding the crossing of the Mississippi may have taken place, and probably did, in the region extending from the Hudson Bay southward to the northern boundary line of Iowa, or some miles farther south. The Snake land is problematical, but seems to have been in Canada. The crossing of the frozen water may have been the crossing of the Rainy Lake, or some of the contiguous waters. Shinaki, the land of firs, is the pine-clad region of northern Minnesota. The Assinapi could not have been the Dakota Assiniboins, but may have been some Indians living in the same rocky region.[7] The Buffalo land may have been the southern part of Minnesota and northern Iowa. The "Yellow" River, where they raised corn, may have been that which by the early French was called "La Jaune riviere," now known as Vermilion River, uniting with the Mississippi a little below Hastings, and it is probable that the Tallegewi, as before, were the effigy-builders of the Wisconsin-Minnesota-Iowa region of the old mound-builders. Their movements through the

[6] The term "Snake" here may mean nothing more than *enemy.* The Algonquian termed the Iroquois *snakes,* also the Dakota, applying to them the term *Nadoue,* or *Nadoway,* or finally *Nadouessi.* The last became with the French *Nadouesioux* and with the English *Sioux.*

[7] The Algonquian words *asin* and *bwan,* from which the term Assiniboin is derived, simply means *stone people.* It is commonly supposed to have reference to the use of heated stones by which they made water sufficiently hot to cook food. But instead it may more probably be referred to the characters of the country in which they lived, which was called by Nicolut the "region of rocks and water." The cooking of food by water heated by stones was not peculiar to them.

country east of the Mississippi, according to one of these renditions, was marked by the friendship and later by the hostility of the Talamatan.

It remains to notice one more interpretation of this tradition, that of the late Dr. D. G. Brinton. On a previous page has been given the arrangement which Dr. Brinton presents of the tribes of the Algonquian, having the Cree dialect, which is that characteristic of the region of northern Minnesota and thence northward to Hudson Bay, at the head of the list. Dr. Brinton remarks of this:

> The dialects of all these were related and evidently at some distant day had been derived from the same primitive tongue. Which of them had preserved the ancient forms most closely, it may be premature to decide positively, but the tendency of modern studies has been to assign that place to the Cree, the northernmost of all.

Accepting this indication for what it may be worth, it certainly points to the Cree, or Kilistino, as being not only more nearly connected geographically with the primitive habitat of the Algonquian, but also as representing their ancestors' tongue more nearly than any other dialect of the Algonquian stock. This will allow the post-glacial migration of that stock from the southwest, as has been supposed, perhaps from Colorado and Wyoming, where they seem still to have a representative in the Arapahoe. The Cheyenne who are now associated with the Arapahoe are later comers, having joined the Arapahoe from the northeast within the historic period. On this supposition, the dialect of the Arapahoe would prove, on close comparison, to be more archaic than all other Algonquian dialects, holding for that stock the same position as that held for the Siouan stock by the Catawba dialect in South Carolina, and the late researches of Kroeber bear out this presumption.

As to the tradition itself, it should be premised that Dr. Brinton, along with Horatio Hale, had a belief that the American aborigines had all migrated from the Atlantic coast westward, having reached America from Europe, derived perhaps from some obscure people in the northern part of Spain. Mr. Hale, who seems to be the chief supporter of this view, in referring to migrations of the Indians quotes only historic movements, which certainly have been largely westward, due probably to the encroachments of the whites since the Columbian discovery. It is simply a geographical and historical accident that we are more familiar with the migrations of the eastern Indians than we are with the western. Under the influence of this preconceived idea, which, according to Mr. W. M. Beauchamp, was based on simply a linguistic "likeness" to one or more of the Indian tongues, Dr. Brinton has taken, it seems to me, great liberties with this tradition, insomuch that he has reversed the direction of the main movement, making it westward instead of eastward, thus making it conform to the direction of historic migrations, with which he seems to think it should be made to agree. He supposes the Lenni-Lenape "at some remote period dwelt far to the northeast, on tidewater, probably Labrador. They journeyed south and west till they reached a broad water full of islands and abounding in fish, perhaps the St. Lawrence about the Thousand Islands." This is quoted verbatim from Dr. Brinton. With similarly violent alterations from the legend, the Lenape are carried into Ohio and Indiana and thence back again to northern New York, having united with the Talamatan (Hurons) to drive out the Talega or Cherokees from the upper Ohio, which they only succeeded in doing finally in the historic period. These alterations from the sense of the tradition, as formerly understood, he claims to be warranted by the discovery of errors in the earlier translations.

The Snake people are relegated to myth, perhaps with correctness. He thinks the legend here relates a conflict between the Algonquian hero-god and the serpent of the waters, a myth which is found also among the Iroquois. After the conclusion of this conflict, the people found themselves in a cold northern country, whence they departed in search of warmer lands. Not recognizing the repetition in the legend of the same story, Dr. Brinton has the Snake war continue on through, and after, the settlement in Shinaki or the "land of spruce pines." Then comes the Lenap 'Allegewi war and the possession of the conquered country.

Neither time nor your patience would warrant me in entering upon a detailed consideration of the validity of the changes introduced by Dr. Brinton. I have carefully examined some of them that have some geographic relation to the country concerned, and will mention only that relating to the so-called "Yellow" River, where, according to the legend, the Lenape dwelt and raised corn "on a stoneless soil." Dr. Brinton considers this stream (Wissawanna) a small river in Indiana, a branch of the Kankakee, saying that on Hough's map of Indian names of Indiana that word has been corrupted to "Wethogan," and that the Minsi, one of the Lenape sub-tribes, were found there in 1721 by Charlevoix, and that they made their first migration from the east about 1690. This involves a historical anachronism, inasmuch as it makes an event occurring in 1690 to 1721 explain a doubtful point in a legend which is wholly confined to prehistoric time. If the Yellow River was first named in 1690–1721 it is not likely to have had that name when the Lenape were waging their war in prehistoric time before they had yet settled in New Jersey. Again the region is said to have a "stoneless soil," which could hardly be affirmed of northern

Indiana.[8] But if the reference of the tradition to a "Yellow" River be not to the Missouri, as has been supposed by some, there is a Yellow River in Minnesota, if another is needed, viz., that now called Vermilion River, entering the Mississippi below Hastings, which, indeed, has a stoneless soil. From there southward extends the "driftless region" on the east of the Mississippi, and in that vicinity are the first of the effigy mounds, *i. e.*, in the Cannon Valley and in Goodhue and Wabasha counties and extending southward, while on the east side of the Mississippi is the central and most characteristic region of effigy mounds. It is not at all improbable that the migrating Lenape made a long halt in the valley of the Vermilion, contiguous to these moundbuilders before they entered upon the great war.

This is the first of the great legends to which I called your attention. The second is that which brought the Dakota tribes into Minnesota, and it doubtless pertains to a time nearly cotemporary with that which refers to the Lenape. It comes to us from the other party to the great conflict, and it no doubt refers to the consequences of the Lenape invasion. This legend is found amongst several of the Dakota tribes, and even amongst the later Algonquian who returned westward to the Mississippi Valley. I will not dwell on the details with those separate tribes, but simply mention the tribes with which it has been handed down from generation to generation, viz., Osage, Omaha, Mandan, Kansa and Akansea, and Ponca. These tribes concur in saying that they formerly dwelt in the Ohio and Wabash valleys, and that they moved down the Ohio Valley, where they were separated into two divisions at the mouth of the Ohio River, some of them going down the Mississippi and some of them up the same river. They repeated such segregation at the Missouri, where, as it appears from the preservation of the name, the Mantane divided into two parties, one of which became the Mandans and the other the Mantanton, the latter being one of the tribes of the Issanti at Mille Lac in 1701 when these tribes were enumerated by Le Sueur, at Fort L'Huillier. The name Issati or Isanti, is itself, apparently, another form of a name of the Siouan South Carolinan Santee, and sometimes, even now, it reverts to the original spelling. If so, they preserved their name during their long residence in the Ohio Valley as moundbuilders.

This tradition is linked in with some historic data in about the same manner that the Lenape migration is linked, and verified by some scant connection with historic events. With this migration the territory of Minnesota was almost wholly occupied by the Siouan stock, and

[8] According to Leverett's late description of the valley of Yellow River in Indiana, the lower reaches of the valley have a sandy loam soil in which the drainage is very imperfect, and the valley for fifteen miles above its union with the Kankakee is narrow. Above that point the Yellow River drains a stony region comprised in the Maxinkuckee moraine. *Ill Glac. Lobe*, p. 507; *Mem. U. S. G. S.*, XXXVIII.

that stock controlled it till the last incursion of the Ojibway from Lake Superior, when, with the great battle of Kathio, another culminating event of the hereditary war took place. This brings us to recent time in Minnesota and it is not necessary to enter upon later tragic events.

There is still, however, one other point to which I wish to refer, viz., in coming to Minnesota those mound-builders who ascended the Mississippi above the mouth of the Wisconsin River returned to their former home. They may have recognized it as the scene of their first defeat by the Lenape, and probably some of them remained there and resumed the construction of mounds. It is admitted by all who have given attention to the subject that the effigy mounds are of a class distinct from and older than the tumuli that are scattered amongst them and which prevail in Minnesota and Dakota. The Winnebago may have been effigy-builders when the Lenape crossed the Mississippi. If so, they must have fled northward from their enemies, instead of southward, and thus escaped the fate of their kindred. They perhaps remained in southern Wisconsin during the whole Lenap'Alligewi war, and so probably welcomed the fugitives on their return. This may account for that curious geographical extension of the Dakota stock on the east of the Mississippi in a narrow tongue reaching Lake Michigan; and it also accounts for the fact that linguistically the Winnebago dialect is one of the oldest of the Siouan stock found in the upper Mississippi region; and further, that the Winnebago are called "grandfathers" by the other tribes.

Thus it appears that the mound-builder dynasty was divided into two parts by a great national misfortune. The Ohio dynasty endured a long period of time. It was probably coeval with the effigy mound-building period or closely followed it. The Minnesota dynasty is comparatively recent, and was short, at the utmost not exceeding 500 years, and extended down to the incoming of the whites.

In conclusion, I can make the merest reference to another prehistoric migration affecting Minnesota, of later date than the preceding. It is well established by coherent and reliable tradition that the Hidatsa Indians, associates of the Mandans on the upper Missouri, also called Minnitari, of the same stock as the Mandans, migrated from Minnesota across the prairie and settled with the Mandans.

We see then that the succession of dynasties in Minnesota is as follows:

1. Algonquian (small area in the southeast also held by the Ohio mound-builders).
2. Siouan, fugitives from Ohio (establishing the Minnesota dynasty of mound-builders).
3. Ojibwa (Algonquian) incursion from Lake Superior, dividing the state with the Siouan people.
4. Aryan civilization.

THE MOVEMENT TOWARDS "PHYSIOLOGICAL" PSYCHOLOGY. IV

By Professor R. M. WENLEY
UNIVERSITY OF MICHIGAN

VI

NOW that Herbert Spencer and Eduard von Hartmann have passed away, Wundt stands almost alone among living thinkers. The importance of his philosophical contribution ranks second only to his epoch-making career in psychology. Time forbids more than this reference to it; but I may add that, very likely, his philosophical attitude possesses a future. For he heads a rising school which holds that a main business of philosophy in present circumstances is to unify and systematize the manifold results garnered piecemeal by the positive sciences.

Born in 1832, Wundt began his academic career as a medical student at Heidelberg in 1851, and continued the same studies later at Tübingen and Berlin, where he resided at the close of Johannes Müller's professorship. In 1856 he worked for a year in the physiological laboratory at Heidelberg under Helmholtz. On the scientific side he came under the influence of Müller, Fr. Arnold (in anatomy), Hasse (in pathology), E. H. and W. Weber, Helmholtz, Lotze, Bain and Fechner. Early in life he also made acquaintance with the philosophical work of Leibniz, Kant, Herbart and Lotze. As stated above,[1] he records that, in psychology, he owes the largest debt to Kant and Herbart; this explains not a few of his later positions, especially those to which younger men, of purely experimental training, have taken exception, without over-much appreciation sometimes, I fear, of what exactly they opposed. His life-work as a teacher and investigator has lain at Zürich, and Leipzig, whither he was called in 1876, and where, in 1879, he set up the first purely psychological laboratory,[2] an example followed since by many of the great universities in all civilized lands. Unlike his predecessors, especially Weber, Helmholtz, Lotze and Fechner, he has not concentrated his attention upon this or that restricted group of psycho-physiological phenomena, but has ranged over the entire field, with the result that psychology owes to him at once

that ever enters high school.

[1] Article I.

[2] I am not forgetting James's laboratory at Harvard in 1875, which was physiological.

its present systematic form and its definite place in the fellowship of the special sciences. For these reasons, his influence and methods have penetrated everywhere.

A bare list of his principal works suffices to exhibit the range and force of his tireless activity: "Beiträge zur Lehre von den Muskelbewegungen," 1858; "Beiträge zur Theorie der Sinneswahrnemung," 1859–62; "Vorlesungen über die Menschen- und Thierseele," 1863, 2d ed., 1892 (Eng. trans.); "Grundzüge der physiologischen Psychologie," 1874, 5th ed., 1902 (Eng. trans.); "Ueber die Aufgaben der Philosophie in der Gegenwart," 1874; "Ueber den Einfluss der Philosophie auf die Erfahrungswissenschaften," 1876; "Logik," 1880–83; "Ethik," 1886, 2d ed., 1892 (Eng. trans.); "System der Philosophie," 1889; "Grundriss der Psychologie," 1898 (Eng. trans.); "Völkerpsychologie," 1900–06; and many contributions of first-rate importance to *Philosophische Studien,* the organ of his laboratory and philosophical circle, since 1881, the first year of its publication. When we remember that four of these books are masterpieces, and that one of them is *the* recognized classic in its subject, some idea of Wundt's importance emerges.

Seizing the opportunity incident to his historical position, Wundt aimed to relieve psychology from the reproach of being merely an instance of more or less loose *descriptive* classification. He proposed to lift it to the level of scientific *explanation.* By what means?

It is experiment that has been the source of the decided advance in natural science, and brought about such revolutions in our scientific views. Let us now apply experiment to the science of mind. We must remember that in every department of investigation the experimental method takes on a special form, according to the nature of the facts investigated. We can not experiment upon mind itself, but only upon its outworks, the organs of sense and movement which are functionally related to mental processes. So that every psychological experiment is at the same time physiological, just as there are physical sciences corresponding to the mental processes of sensation, idea and will. This, of course, is no reason for denying to experiment the character of a psychological method. It is simply due to the general conditions of our mental life, one aspect of which is its constant connection with the body.[3]

Or, again:

Psychology is compelled to make use of objective changes in order, by means of the influence which they exert on our consciousness, to establish the subjective properties and laws of that consciousness.[4]

Or, once more:

Physiological psychology is, therefore, first of all *psychology.* It has in view the same principal object upon which all other forms of psychological investigation are directed: *the investigation of conscious processes in the modes*

[3] "Human and Animal Psychology," p. 10 (Eng. trans.).

[4] *Philos. Studien,* I., p. 4.

of connection peculiar to them. It is not a province of physiology; nor does it attempt, as has been mistakenly asserted, to derive or explain the phenomena of the psychical from those of the physical life. We may read this meaning into the phrase "physiological psychology," just as we might interpret "microscopical anatomy" to mean a discussion, with illustrations from anatomy, of what has been accomplished by the microscope; but the words should be no more misleading in the one case than they are in the other. As employed in the present work, the adjective "physiological" implies simply that our psychology will avail itself to the full of the means that modern physiology puts at its disposal for the analysis of conscious processes.[5]

But, had he gone no farther than this, Wundt could scarcely be excepted from the condemnation of his predecessors, or from that under which some of his scholars have fallen. For, plainly, it could be objected that he had omitted the two most remarkable facts of consciousness which, stated synoptically, are its *intensive* or individual centralization, and its *extensive* development in society. These aspects of the matter tend to get beyond psychological management, as they assuredly raise ultimate philosophical problems. Wundt's high distinction is attributable mainly to his recognition of and attack upon these difficulties. So, his psychology offers a second, and broader, side, set forth, for example, in his excursus entitled "Philosophie und Wissenschaft" ("Essays," 1881), and present as a constructive, possibly a disturbing, element, in his entire purview of the psychological field. For instance, in his "System," the theory of the "growth of mental values" bears precisely upon these questions. "Mental life is, extensively and intensively, governed by a law of growth of values: extensively, inasmuch as the multiplicity of mental developments is always on the increase; intensively, inasmuch as the values which appear in these developments increase in degree."[6] And, on the strictly psychological side, he takes note of the same things as follows:

We may add that, fortunately for the science, there are other sources of objective psychological knowledge, which become accessible at the very point where the experimental method fails us. These are certain products of the common mental life, in which we may trace the operation of determinate psychical motives; chief among them are language, myth and custom. In part determined by historical conditions, they are also, in part, dependent upon universal psychological laws; and the phenomena that are referable to these laws form the subject-matter of a special psychological discipline, *ethnic* psychology. The results of ethnic psychology constitute, at the same time, our chief source of information regarding the general psychology of the complex mental processes. In this way, experimental psychology and ethnic psychology form the two principal departments of scientific psychology at large. They are supplemented by *child* and *animal* psychology, which, in conjunction with ethnic psychology, attempt to resolve the problems of psychogenesis. . . . Finally, child psychology and experimental psychology in the narrower sense may be bracketed

[5] "Physiological Psychology," Vol. I., p. 2 (Eng. trans.).

[6] "System der Phil." (2d ed.), p. 304.

together as *individual* psychology, while animal psychology and ethnic psychology form the two halves of a *generic* or *comparative* psychology.[7]

So far the *extensive* development. On the side of *intensive* centralization Wundt's doctrine of apperception provides the necessary hypothesis. To these aspects of the subject I can only refer now.

Turning at once to the "Physiological Psychology," we find that it proceeds, as scientific method dictates, from the simple to the complex. After an introduction, Part I. discusses the bodily Substrate of the Mental Life; Part II. the Elements of the Mental Life; Part III. the Formation of Sensory Ideas; Part IV. the Affective Process and Volitional Action; Part. V. the Course and the Connection of Mental Processes; Part VI. adds Final Considerations. Thus, we pass from the functions of the nervous system, by way of sensation, feeling and presentation, to consciousness in the formation of ideas and in the train of ideas, which, in turn, involves attention, apperception, and will, not forgetting phenomena such as association, imagination and emotion. Two reasons make it hard to select this or that, and to say, Here Wundt excels. First, profuse wealth of suggestion and result is scattered everywhere. Second, the successive editions of the "Physiological Psychology" constitute the life history of Wundt's own mind in relation to the subject as a whole; and only psychologists *von Fach* can supply the necessary light and shade. It appears to me that special interest attaches to his discussion of Müller's theory of specific energies, because it reveals Wundt's view of the part played by the nervous system in the psychological organization; to his criticism of the Young-Helmholtz theory of color, because it attacks the "mystery" of space-perception; to the treatment of sensation, the duration of mental processes, and association, because they afford typical instances of the new data which experimental psychology can bestow upon analyses of psychical phenomena. Doubtless, professed psychologists would insist upon other points. For my part, the central interest still attaches to Wundt's theory of apperception and will. I take the former as a typical illustration of the *direction* in which physiological psychology moves.

In apperception the conscious being brings his entire unity of experience to bear on the object now in the field of his attention. We light upon an inner and elaborative activity which "bears the stamp of spontaneity." Evidently, a process complex in the highest degree! My expert colleague, Professor Pillsbury, has analyzed it as follows: Apperception involves four elements. "(1) Increase of clearness in the idea directly before the mind, accompanied by the immediate feeling of activity; (2) inhibition of other ideas; (3) muscular strain sensations, with the feelings connected with them, intensifying the

[7] "Physiol. Psych.," Vol. I., pp. 5-6 (Eng. trans.).

primary feeling of activity; (4) the reflex effect of these strain sensations, intensifying the idea apperceived."[8] Despite this complexity, the apperceptive theory posits fundamentally a necessary "original activity," or "psychical energy," which arises from within consciousness and transforms, as by a synthesis, what, for convenience sake, may be termed simple factors. Physiological stimulus pales, and subjective transitiveness becomes determining. This activity has close connection with will, often with choice. How can it be explained? With Wundt the term consciousness possesses a special and restricted meaning. It consists of all contents, such as feelings, ideas, excitations of the will, and—there is *no underlying substance or occult being.* This represents the analytic aspect; the synthetic remains to be reckoned with. Now, the spontaneous activity of the mind itself, whereby presentations come to be distinguished clearly, appears as *appercipient attention,* when brought to play upon perceptions or upon the "stream of consciousness," and as *volition,* when it originates movements of the body. Obviously, the former is the more fundamental, because, in it, I connect my ideas with my will. It "depends, on the one hand, upon the stimuli then at work; and, on the other hand, upon the total state of consciousness, how it is made up that is, by present impressions and prior experiences. . . . If we would describe more nearly what it is that we experience in ourselves when pleased or pained we can not do this more concretely than by denoting pleasure as a straining after, and pain as a straining against, an object."[9] We may say, then, that apperception means will brought to bear upon states of consciousness and then directed to external muscular acts. For, "there is absolutely nothing outside man or in him which we can call wholly or entirely his own except his will."[10] So Wundt finds the existence of a synthetic activity of consciousness *beyond the range of mere association.* Without going far wrong, we might term this the single faculty into which all the faculties of the old psychology are absorbed. For it compares and selects among conscious states; or peradventure, it can be described as a species of conscious striving. Here, then, the mental unity presents its distinctive, differentiating nature, and, as some have indeed supposed, might be held exempt from the persistent sapping of psycho-physiological method, secluding itself within its unattainable citadel. But this is a complete mistake; and I take the opportunity to call attention to Wundt's modern position even here, a pronouncement the more necessary that he has been so frequently misunderstood, strangely enough, by those who ought to know better. Apperception, or what you please, happens to be an undoubted fact of mental life. Accord-

[8] *Am. Journal of Psych.*, Vol. VIII., part 3.

[9] "Physiol. Psych.," p. 535, Vol. I. (3d ed.).

[10] "System d. Phil.," p. 387.

ingly, it must submit to experimental treatment. A process exists, therefore analysis is free to track it to its lair. And, especially when the problem of duration raises its head, as it does inevitably, a cumulative series of experiments is in strict order.

What happens when apperception occurs? Generally, of course, a transformation of sensory into motor activity. In detail, according to Wundt, a train of processes has supervened, *viz.:* (1) Transmission from the sense-organ to the brain; (2) entrance into the "field of view," that is, existence of simple perception; (3) entrance into the "point of view," when perception becomes discernment; (4) activity of will, with innervation of the central organism through the motor-nerves, and (5) the resultant excitation of the muscles. Plainly, the crux hides in (3), which is purely psychological, while the others have a clear physiological reference. Nevertheless, (3) happens to be so surrounded by physiological phenomena that it is open to observation and experiment and these methods have been concentrated upon a research into the cerebral changes which accompany perception, apperception and will, respectively.[11] These experiments, although elaborate, and becoming more elaborate, may be classed under three heads. (1) The investigation of simple physiological time, that is, when the subject is aware of the coming impression, but is ignorant just when it will take place. (2) Those in which even this element of ignorance is eliminated. (3) Those in which modifications are possible widely, because, for example, the subject does not know what the impression will be, or is unaware of the character of the stimulus in such a way that he does not know how precisely he will be called upon to register it. In combination, these experiments show, as Wundt infers, that the exact moment of appercipience is dependent upon the self-accommodation of the subject, particularly in the matter of attention. Take the third case:

> An indicator is kept moving at a uniform rate over a graduated scale, and so situated that the place of the needle can be clearly seen at each instant of time. The action of the same clock which moves the needle causes a sound at any moment, but in such a way that the subject of the experiment does not know when to expect it. With what position of the needle, now, will the sensation of sound be combined? Will the sound be heard exactly when it occurs, as indicated by the needle; or later than its real time ("positive" lengthening); or earlier than its real time ("negative" lengthening)? The result shows that one rarely hears the sound without either positive or negative displacement of it; but most frequently the lengthening is negative—that is, one believes one hears the sound before it really occurs as measured by the indicator.[12]

In this connection, then, the fundamental problem of physiological

[11] Cf. Cattell in *Mind*, XIII., pp. 37 ff. (old series), and Titchener in *ibid.*, I., pp. 206 ff. (new series).

[12] "Elements of Physiological Psychology," Ladd, p. 488.

psychology is, "to determine the simple reaction-time, and from it to find the factors of psycho-physical time—namely, perception-time, apperception-time (or discernment-time), and will-time."[13]

Along this line laboratory investigation has been able to show that the will does, as a matter of record, occasion changes in the central physiological mechanism, and that these changes possess *quantitative* differences having more or less definite relation to psychical activity. By this I understand that the latent energy of the nerve-cells is summoned to activity, and that, as a result, the brain labors hard. In our own laboratory I have seen the subject of an attention experiment pour with perspiration, although physically he was, to all appearance, quite quiescent. No better proof of intense cerebral work could be desired. And experiment simply attempts to relate this energizing to the concomitant psychological states.

But Wundt has committed himself to the modern attitude even further. In the first and second editions of his "Physiological Psychology," he suggested that the frontal regions of the brain are related to apperception as the "bearers of the physiological processes which accompany the apperception of the presentations of sense."[14] In other words, all stages of the apperceptive process are accompanied by a fixed physiological activity. Beyond the circumstance that this assigns a function to the frontal regions which, otherwise, stand out of distinct relation to the factors of consciousness, it must be regarded as a speculation. Wundt himself, although he does not dismiss the hypothesis, tends to minimize it from his third edition. Yet it serves to show how persistently he clings to the true psycho-physiological method even in regard to the most recondite operation of the mind.

It remains to note that the influence of mind over body demands study as much as the converse. If apperception be a legitimate supposition—and it would seem to be a hypothesis which at least accounts for unquestioned facts, then it follows that we must estimate it, not by external stimulus, but in terms of internal activity. And this, of course, reminds us that psycho-physiological investigation has proved the existence of an influential voluntaristic element. No doubt, to this point, the former has claimed, and still claims, the lion's share of experimental attention. So that, in many ways, the internal problem awaits concentrated attack. That is to say, physical and physiological problems, being so much more readily amenable to the new methods, have tended to crowd out the distinctively psychological material. Nevertheless, we have arrived at something *analogous* to a *causal* influence of the central nervous system upon what I shall call ideation. This was the indispensable initial step. But yet, this causality is

[13] *Ibid.*, p. 472.

[14] Second edition, Vol. I., p. 218.

necessarily in consciousness, and, in so far forth, is not causal at all. For, of nervous states as such we do not know anything, and never can know anything. Accordingly, the other side proffers its claim, which, in the light of this agnosticism, is very far from being modest. This point was admirably taken by Professor Cattell, in his vice-presidential address to the Anthropological Section of the American Association for the Advancement of Science, in 1888:

> Much is being written just now regarding the relation of consciousness to the brain. The question is: Do perceptions, thoughts, feelings, volitions, stand in causal interaction with the brain, or are they an epiphenomenon, accompanying changes in the brain but not influencing them? Are our ordinary actions complex reflexes due to physical stimuli and the structure of the nervous system, or are the changes in the brain that precede movements initiated and directed by consciousness? The question is one of facts that should be settled by scientific methods; and the solution will by no means concern psychology alone. The two greatest scientific generalizations of the present century are the conservation of energy and evolution by the survival of the fit. Now, if consciousness alters, however slightly, the position of molecules in the brain the fundamental concept of physical science must be abandoned. If consciousness have no concern in the actions of the individual we have one of the most complex results of evolution developed apart from the survival of useful variations, and the Darwinian theory has failed.[15]

We conclude then with the startling reflection that psychology is the keeper of a tremendous oracle. And, on the whole, the oracle keeps silence still.

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[15] P. 12.

THE PRACTICAL VALUE OF PURE SCIENCE

By Professor THOS. H. MONTGOMERY, Jr.
UNIVERSITY OF PENNSYLVANIA

THROUGH all ages men have asked, What is worth while? The answer has been, at least from those not stupefied by pessimism, that many things are worth the while: happiness, self-respect, health, friendship, honor, wealth, all these are worth having, and any work that helps to secure them deserves the undertaking. It is the old question of what man should try to attain, and about it many a system of philosophy has reared itself, though for the most part on shaking legs.

Through this conflict of opinion we have come to pride ourselves upon being practical, even to such an extent as to consider abnormal any one who does not share this quality. To be practical means to be able to turn knowledge to useful account, to make of it some rather immediate application. With us Americans to be practical means too often to make and save money, forgetting that money is only a tool. Personally I would hold that man to be most practical who gets the most happiness out of life. But at the present we are concerned only with the question, that may seem a paradox, how can pure science be a practical undertaking?

Science in the strict sense, or pure science, is the search for the explanation of things. It is not the collecting of statistics, nor the cataloguing of them, nor the construction of systems, for however much these operations may help science, they do not compose it. Science is the light that points out what different phenomena have in common, and establishes their origins and changes. To-day the term is often taken in vain, as when we speak of pugilistic, tonsorial and domestic science, which shows that the general idea of it is any special skill or knowledge. But pure science, as strictly used, is much more than either skill or knowledge, it is explanation without any thought of immediate application to human needs.

How, then, is pure science practical, when it avowedly seeks no quick useful end? It is so, as its records show, by serving as the pioneer that makes possible utilitarian ends, it breaks a road through the unknown for application to follow. For not until science has given the explanation can we turn that explanation to use. And the examples that I shall proceed to relate show clearly that the pursuit of pure science has made possible many of the benefits that we now enjoy.

It would be well worth while to stop to consider how much the various branches of engineering owe to pure mathematics and pure physics; or to relate the rise of numerous great industries that have grown out of the theoretical study of chemistry. Where would be our electric lighting and transportation but for the explanations of Franklin, Volta and Faraday? But I will limit myself to the practical value of pure science as exemplified by a particular one, biology. In making this restriction I should add that history tells how each of the pure sciences has led to useful ends, so that biology is but one of several cooperating sisters, each making her contribution to greater human happiness.

Biology has to explain the nature of living energies in treating of animals and plants and of man himself. Biology has to interpret processes, and this it attempts to do in a variety of ways according to the nature of the problem, the material and the bias of the thinker. Biology has to some extent grown up side by side with medicine; each helped the other in the days of their beginnings, and for that reason we may first treat its practical bearings to medicine.

In the seventeenth century the microscope came into use and it opened up, in the hands of Leeuwenhoek and Schwammerdamm, a wealth of unexpected detail. Leeuwenhoek exhibited his dissection of an ant to the delighted eyes of a king; since that time the tastes of royalty seem to have deteriorated. But such discoveries in the finer details of anatomy only presented new problems. The partial explanation came in 1838 with Schleiden and the following year with Schwann, who stated that animals and plants are built up of definite living units, the cells; that such units compose the tissues that had been determined by the physiologist Bichat, and that the organs are composed of definite layers of cells. The simplest animals, what we now call the Protozoa, were shown by Dujardin to be each composed of only a single cell. We define a cell as a particular mass of living substance regulated by a particular center, the nucleus. This view was strengthened by the notable researches of particularly von Kölliker and Max Schultze, and so gradually extended to all animals and plants as well as to the human body. Eduard van Beneden later finally settled the fact that the egg, the beginning of each many-celled animal, is itself a single cell. Thus biologists have come to concentrate their attention upon cell activities, and this cell unit has proved as fruitful in biology as the atom in chemistry, though the cell is something vastly more complex than many atoms. Now there grew up with this new doctrine Rudolf Virchow, the great master of the study of disease, and he it was who by placing the study of disease upon the cellular basis, by tracing diseased conditions to particular cells, laid the rational foundation of one branch of modern medicine. The investigation of the structure and function of cells is to-day regarded as the basis of research in medicine as well as in biology. Yet all of it is traceable to the dissection of an ant beneath a crude microscope! Surely nothing would have seemed less likely to have had practical bearings.

Such studies have given also the basis for embryology, the analysis of the development of the individual. Perhaps the greatest marvel of nature is the growth and change of the individual, a process that is ever before us, yet considered by few. From a microscopic egg cell that shows but few differences in its various parts, grows up the adult body with its manifold organs; hairs and muscles, bones and lungs, these are not present as such in the egg cell, yet they gradually arise out of it and in the order of their use. The problem is: is such development regulated by energies of the egg cell, or by the operation of new stimuli and energies as the development proceeds? The marvel is the astounding precision of the process in spite of its complexity. When you eat your morning egg glance at the yellow yolk ball and note at one point of its surface a small white disc; that is the egg cell proper, all the rest is simply food for it. Now try to think out how that little disc produces the complex fowl, and you will agree that the problem is a much harder one than the fluctuations of stocks in your morning paper. This problem has also a close bearing on medicine, as William Harvey pointed out some three centuries ago and more, for the development of the human body is as important to the physician as its anatomy, because the anatomy is but one view of the individual, while the development represents the whole. To understand our own bodies we must know how they are formed, and to understand disease it must be traced to its origin. The changes from the egg cell to the adult demonstrate that the longer a part develops, the more precise and fixed it becomes, so that finally each particular part comes to have one definite structure, position and use. Malignant growths, then, probably have their causes most frequently early in development, due to misplacement of cells, temporary arrest of growth, undue rapid multiplication of cells, and other abnormalities. But this is not the place to attempt to classify diseases on an embryological basis, such as has been done by Minot. We need note here only that medicine is beginning to tread in the path made by biology, in recognizing that human disease as well as human anatomy must rest on the foundation of development.

Then, to understand our own bodies we have to explain them in terms of the structure of other animals, and many of our parts would be meaningless to us but for a knowledge of comparative anatomy. Our cankered vermiform appendix is represented in some animals by a large and serviceable attachment of the digestive tract, which explains it as a degenerate organ and therefore necessarily variable. Deep between the hemispheres of the brain is a little sac about the size of a pea, the pineal gland, and comparison shows that this was once a third eye. Sometimes an opening persists on the side of the neck below the jaw; in such a case one of the embryonic neck clefts has remained open, and this in turn has relations to the gill slits of a fish. All the ground plan of our bodies, the muscle cylinder within the skin, next the bony scaffolding, innermost the peritoneal sack around the viscera, all such relations would remain a mystery did we study only the human body. But in the light of comparative anatomy and embryology we recognize them as necessary parts of our heritage. Medicine must stand upon a thorough knowledge of the structure and processes of the human body, and before it can treat disorders it must understand states of health and their origin. Comparative anatomists and embryologists, the great men Harvey, Wolff, von Baer, Cuvier, Agassiz, Huxley, Cope and Gegenbaur, such men have not only broadened the field of human thought, but have also furnished the understanding of the human organism. They were all pure scientists, they did not have in mind the care and cure of the human body. Yet we might say they accomplished more for a rational medicine than all the physicians before them. How unlikely the prophecy seemed that any direct advantage would come to mankind from the researches of Harvey, Wolff and von Baer on the development of the chick, from those of Cuvier and Agassiz on fossils, or from those of Huxley, Cope and Gegenbaur on comparative anatomy. As the result of this change of thought we now see most medical schools prescribing biological courses, and choosing their professors of anatomy largely from the ranks of embryologists.

It is hardly necessary to state that it was Louis Pasteur who laid the foundation for the study of disease-producing organisms; indeed, he may be said to have done more for the human race, more to prevent physical misery, than any other man of the nineteenth century. He had in mind, first of all, the cure, but he realized that to accomplish this the mode of transmission of the disease must be understood. There have followed him a long line of investigators of bacterial diseases, and among them the purely scientific have done quite as much as the purely practical. In Russia there was a celebrated embryologist, Elias Metchnikoff, who worked out the life histories of a variety of animals, and was thereby led to a consideration of the part that the white blood cells play in the development. This brought him to the view that such cells are the guardian policemen of the body, that seek out and destroy the bacteria; and this to the further idea, that health is to be maintained and infection prevented by keeping the white blood cells in proper numbers and activity. Metchnikoff succeeded Pasteur at Paris, and though his theory of phagocytosis is far from all-sufficient, it has nevertheless strongly stimulated the study of bacteriology. His practical ideas grew out of his theoretical investigations of insects and worms.

Just at the present time the center of interest in medicine is the study of those infectious diseases produced not by bacteria, but by other one-celled germs, the animal protozoa. Among them are the blood parasites that produce malaria, yellow fever, syphilis and the terrible sleeping sickness of Africa, as well as the intestinal parasites of bloody dysentery; another one of them produces the Texas fever of cattle. Many investigators have contributed to our knowledge of these diseases since the time when Laveran discovered the germ of malaria, and prominent among them are the names of Grassi and Schaudinn. Grassi is professor of zoology at Rome, well known for his researches on the ancestry of insects, on the social communities of the white ants and on comparative anatomy; these researches on unpractical subjects furnished him with the method for attacking the malarial germ, and for making the marshes around Rome nearly free from that disease. Schaudinn worked at Berlin on the life histories of salt-water protozoa, discovering much of broad theoretical importance, indeed with much greater success than the long line of naturalists before him. He was no physician, he was a biologist, yet he ultimately attained one of the most desired medical chairs in Germany. His genius, and in a measure he is to be compared with Pasteur, lay in his success in unraveling complex life histories; he learned the method in studying the free-living forms, and therefore was enabled to work out the life histories of several that endanger the human body. He never had any direct interest in practical medicine, yet what help his work has brought to medicine! What he did in this direction, the zoologists Leuckart and Leidy did in another by their discoveries on the parasitic worms of man, and on the mode of infection; they all had little thought of practical application. Such biologists have taught pathologists that in the cure of any infectious diseases the first thing to be determined is the life history of the parasite, and this subject is a biological one.

Besides seeking the prevention of disease man has to meet the natural struggle for existence in another way, by securing food, and this means the nurture of his flocks and crops. Here again pure science has proved a valuable pioneer. Naturalists have long since recognized the close dependence of species upon each other, that what affects one comes in the long run to affect all. This is a dependence based upon the struggle for food. Remove one element, as one species, and a more or less general profound disturbance follows. Mankind is in no way exempt from this law. Decimate or extirpate a particular kind of insect-eating bird, and the insects that formed its diet will increase in numbers. Man will feel the disturbance should such insects happen to affect vegetation that is of human use. Remove the timber from mountain lands, and the available water will decrease, because the timber helps to hold the water supply and to prevent floods. In any way change the face of nature, as man by his habits must needs to do continually, and more or less serious results must follow. As an instance we may consider the cotton boll weevil, a subject that is a remarkably earnest one in Texas. This insect originated in Central America and has spread northward; several years ago the natural barriers to its spread were broken down and consequently it has extended its feeding area. When it first appeared in Texas all sorts of rough remedies were applied, but in vain; then the help of the National Department of Entomology of the Bureau of Agriculture was called in. They responded by sending down experts: not men trained in boll-weevil methods, for these had to be learned, but men with a good knowledge of general entomology, ready to attack the matter as they would any scientific problem. First they proceeded to determine the life history, egg-laying habits, duration of the different developmental stages, number of broods, overwintering; then, knowing these facts, they could decide at what stage the injury may be most successfully fought. The method is of the first importance and this was given by pure science, and in a way the method of meeting the boll weevil is not unlike the method of fighting a parasite of the human body. The next step was to ascertain the natural animal and plant enemies of the pest, and to try to increase these enemies. Thus the field mice in Russia have been reduced by infecting them with pathogenic bacteria, and the "green-bugs" of wheat by increasing the number of lady beetles. These are the general methods of meeting any such practical questions. Farmers may laugh at naturalists, but they are wholly dependent upon them when such emergencies arise. Most of us are likely to smile at the man who collects and describes insects, counting the number of joints in the antennæ of a bug, of hairs upon the forehead of a bee, or the arrangement of the veins upon the wing of a moth. Most people would hold that such a being is wasting his time in a foolish hobby. But I wish to drive the fact very firmly home, that the collecting and naming of animals and plants, occupations that even many biologists pity, are really fundamental for biology and therefore for the sciences that rest upon biology. For the study of animals and plants had reached a standstill, a stagnation, for want of a proper concise method of naming the numerous species that were being made known, until the great Swede Linnæus, in the middle of the eighteenth century, by originating the modern method of naming plants and animals, indirectly made possible advance in agriculture as well as in biology. The more our knowledge advances the greater grows the need of accurate determinations of species. Without systematic describers of species agriculture would be a hopeless matter. Thanks to the labors of generations of pure scientists, working for the most part in obscurity, most of the insects in each civilized district have been described and named, and much has been made known concerning their habits. This knowledge is about as important a tool to the husbandman as is his plough.

In passing it need only be mentioned that the agitation for the protection of native birds, a movement that the farmers are at last beginning to support, originated not with agriculturists, but with scientific ornithologists. The farmer, left to his own prejudices, would kill all birds.

In another way pure science has aided agriculture, in improving varieties. The chief method in use is selection, planting each new generation from the seeds or cuttings of the best plants of the previous one; the most fit are selected and propagated. This method has been in use for more than a century, but it is only within the past fifty years that it has entered into general systematic employ. The man whose labors brought this method into dominance was Charles Darwin, who proved how important a factor selection is in the perpetuation and guidance of the changes of living beings. Now Darwin was not called a practical man; he was first an insect collector and geologist, then a traveler, lastly a most conscientious experimenter with an eye single to explaining. He discovered a natural factor in evolution, and illustrated it so fully on both wild and cultivated species that the world has accepted its truth. Before him men had applied selection rather unwittingly, on the general assumption that "blood will tell." After him they saw clearly into the workings of the principle, and now experiment with a fixed method. It is Darwin's method that the Department of Agriculture is trying to teach the farmers.

Then much work has been done to secure improvement by the crossbreeding or hybridizing of different varieties. It was Darwin again who was the first broadly scientific investigator of such inheritance. Take two plants or two animals which differ in one or more qualities and cross them, then it is to be expected that the hybrids will differ from the parents, and that a new strain or breed may be obtained that will prove more favorable for our particular purposes. Much of this kind of experimentation, perhaps the greater part, has been done so far by practical animal breeders and gardeners, and it was from such records that Darwin obtained much of his information. No one, for instance, has carried it out more extensively than Burbank, and he has had in mind marketable returns. Yet the theoretical study of hybridizing is coming to aid the other, and in time may come to direct it. Different kinds of inheritance are now distinguished, as blended inheritance, when the hybrid is intermediate between the two parents; mosaic, when it has some of the characters of the one and some of the other; alternate, when some of the hybrids are like one parent and some like the other; and the so-called unisexual inheritance, when all the hybrids tend to resemble one particular parent. Entirely new and unexpected fields of experimentation have been brought out by Mendel's study of alternate, and De Vries's examination of unisexual inheritance. This theoretical work also teaches that in practise attention should be given not so much to the whole individual as to the particular quality desired. The remarkable work of De Vries, the most important in evolution since the time of Darwin, would tend to show that though new forms may be produced by crossing, such crosses are usually not permanent, but tend to revert. De Vries's particular contention is that stable new forms, those that breed true, are not produced gradually by selection or otherwise, but arise suddenly and only in particular mutation periods. This introduces an entirely new attitude in the matters of selection and cross-breeding, and there can be no doubt that the scientific decision of these great problems will come to exert a great influence upon the progress of agriculture. It is the work of theorists that is here directing, stimulating and explaining, and it is changing the present haphazard experimentation, with its great loss of time and money, into accurate control.

If farmers would only do a little experimenting on their own account, each laying aside a small piece of ground for making tests, they would learn more of practical advantage than by following, year in and year out, the methods handed down by their forefathers. They would be doing a little scientific explanation, and though this might not immediately give them an additional bale of cotton, in time it would give them much more than that and would fill them with greater interest for their daily labors. The farmers are the backbone of the nation, and that spine must not get the rheumatism. A man must look before he leap, and science does the looking. As Franklin put it: "The eye of a master will do more work than both his hands." Indeed, the farmer comes into close touch with biological problems because his business is directly with plants and animals, and though he does not know it he is really a biologist in the rough. When the competition for market becomes keener, and it continues to do so as men become more trained, only he will be able to succeed who is armed with a working theory and by means of it aims at better results. In farming it is not the land so much as the man. To get at a new plan so as to use his time and brawn to the best advantage, the farmer must begin to explain and must use the explanations of science. A hen can not grow into a rooster, but it can be made to lay two eggs a day. The question of the qualities and possibilities of living beings is the subject-matter of biology, and the more we understand them the more we can use them. But we must remember that we can apply only when close study has suggested a method, and for that preliminary study to be effective it must not be hampered by the thought of immediate practical returns. Had Darwin in mind the improvement of domestic races of pigeons and poultry instead of the explanation of their origin, he would have contributed much less than he did to be put to practical use. Therefore the farmer should cease to look upon biology as an expense and luxury meant to entertain rich men's sons; he should recognize that any laboratory that is helping tc analyze the energies of life is contributing something, indirect but none the less important, to further our usage of plants and animals.

These views are by no means generally held; they have to be taught. To transmit the new ideas of each generation is the business of teachers, and we may now discuss what kind of men make the best kind of teachers. To this I would answer that, other things being equal, the investigator makes the best teacher. For the teacher's duty is not so much to inform as to interest, and the greater interest he has in his own subject the greater influence he will be likely to have over his pupils. Clearly, then, the investigator should teach well because he has the enthusiasm to undertake the difficult task of advancing his subject. Further than this, he can best treat his subject because he has won knowledge for himself as well as through others, he most fully realize the difficulties and problems, and he should be the least likely to pin his faith to unfounded theories. On the other hand, that teacher can not have great influence who has learned simply from his school and college courses and from text-books, and who has not tried to penetrate into the fascinating field that lies beyond. Louis Agassiz was the greatest teacher of natural science that this country has yet enjoyed, and he was through and through an investigator; take the example of any man whose students have been led to follow his profession, and you will find he was an original thinker. One man may be a very storehouse of detailed information, yet be unable to teach, for too much knowledge is an impediment to clear thought. Another may be ignorant of many things, which is really a desirable quality, and because of his creative spirit of research be an inspiring teacher. The teacher's business is not to drill his students so that they soak in facts like so many sponges; but he should give them the wish to blossom and break into fruit of their own. Were encyclopedic knowledge the ideal, one generation would receive the knowledge of the preceding, no more, and the centuries when such conditions prevailed were well termed the dark ages. The teacher should create as well as transmit, for creation strengthens his teaching quality. Thus it happens that in the long run it is pure science that is forwarding every movement in general education. We find a parallel in the case of musicians: there are many with a good technique, but very few with the power to compose; the former are copyists and the latter creators. Now, what could the technicians do without the composers? Appliers are dependent upon fertile creators in general education as in music and other matters. It is pure science by which a man can advance his subject a little and arouse his students to do the same.

It may seem a sweeping statement, but I am inclined to believe that any advance in pure science helps to better our race, whether all of it can be practically applied or not. For so many practical uses have been made from what seemed unpromising theories, that we may confidently expect still more applications in the future. That is one side of the subject. The other and the more important is the growth of the method of science, to never rest content, but to seek to explain more and more. This means a continuous expansion of the field of thought and will prevent crystallization and stagnation. Just because human progress is to such great extent mental, creative thought should be held an important ideal, and this is the essence of science. Thus the mere pursuit of science, whether it be of direct material advantage or not, is by no means worthless to us, for it is a powerful factor in the progress of the human mind. I do not believe in the argument of the schoolmen, that a subject is to be studied for the mental training; life is too short for duties of that kind; what we need is the introduction of more subjects that enlarge our interests, and teach that there is a great deal under the sun that is new and inspiring. My particular argument may seem to many rather specious, yet I think that just in this point is pure science of great value. Men ask for quick, tangible results, for early harvesting of the crops. But that which is easiest and quickest need not be best. What influence each of us most deeply in our personal lives are intangible matters, feelings and desires that are hard to define and that are set apart from the daily occupation. Just so it is with our progress from generation to generation; it is the clarifying and ennobling thought rather than the dollar that gives the most enduring satisfaction whether we are ready to admit it or not. And if you ask proof for this statement, you may find it in any national biography where you discover the names of thinkers, not those of mere money-getters.

Our advance in civilization consists to large extent in the perfecting of the social state, and herein lies the important task of sociology. Numerous have been the proposals for bettering social conditions, and as great the clash of view, for such questions press on all of us. All admit the imperfection and injustice of present conditions, yet there is no general remedy in promise. The most we seem able to do is to mitigate here and there a few of the most urgent evils. It would seem that economists have dealt with only parts of the problem; they have spent much time in definitions, but so far have missed giving a scientific foundation to the whole subject. For in their examinations of human communities and governments they have limited themselves to man, and to large extent to man within the periods of graven and written history. The chief criticism that biology presses on sociology is that sociology has not yet taken the broad comparative and genetic method. The physician has learned that to understand the human body he must constantly make comparisons with the lower animals; indeed, the progress of medicine, as we have seen, is due to such a method. The psychologist is also recognizing that to explain human mental states he must go back of man; must trace mind from its beginnings, for biologists have shown that even the simplest one-celled animals exhibit memory, attention, volition as expressed by choice, and still other mental states. But so far the sociologist appears to have missed this method and has also failed to go back to the beginnings of the social state. Would you say that it seems ridiculous to expect complex social life among the lower animals? Biology has made known animal communities that in all respects are more fitted to their conditions of life and more harmonious than ever was human society. Nearly all conceivable social states are exhibited by animals. For there are associations of entirely different species of animals, even of animals with plants, the condition known as symbiosis, where each is necessary to the life of the other; this is a life partnership. There are quite opposite kinds of social conditions, parasitism, where the one gets most of the benefit and the other most of the injury; this animal parasite has its resemblance to the human plutocrat. Again, there are associations of individuals of the same species, societies that have developed out of the maternal instinct, the instinct of the mother to care for her young; the social state has arisen in such cases by the mother remaining with her young until the latter are full grown. The beginning of the family we find in the mother fish who guards the young against the father, or the spider who carries her young upon her back; endless are the curious instances of such single families. Out of these have arisen higher social states by the young remaining together after maturing, held together by the control of the mother. In the animals this is generally a matriarchate, or at least a feminine rule, for among the lower animals it is the males that have no suffrage. Thus has grown up that wonderful socialism of the honey bee, admired by men since the beginning of history. Here the queen mother is the single reproductive individual, wherefore she is guarded and fed; but save for her annual outburst, a pettishness allowed to royalty, when she leads a swarm out of the hive, she is virtually a prisoner and the government is carried out by the workers, who regulate the life of their queen more precisely than we are able to do by any written constitution, while at the same time they gather all the food, pasteurize and store it, nurse the young, secrete the wax and build of it the geometrical comb, even ventilate the hive. No wonder that men sit for hours in their gardens contemplating such organized unity. The drones, they represent a plutocracy, they have but one mission and when that is accomplished the workers kill them. Different wild bees and wasps exhibit various stages leading up to this complex state. Yet still more wonderful governments are known among the ants, with their different castes of workers, each with its particular set of occupations, with their more complex nests with granaries, dining-chambers and bed-rooms; with their habits of harvesting, of keeping milch cattle and providing stables for them, of cleansing the young, of growing and tending mushroom beds, true vegetable gardens beneath the earth, with even the habits of keeping slaves and guests. Ants also have a language by which they communicate their ideas to each other, not by articulate words, but by touch and smell; and certain solitary wasps are known that make use of a stone as a tool, a faculty generally supposed to be limited to mankind.

Now, such cases have been discovered by biologists, and biologists are analyzing their evolution. Pure science has made them known for the pleasure of the work and of the explanation. Yet it is not idle to suppose that such study may yet have its bearings on human social problems. Three practical men have turned with profit to the study of the social life of insects: McCook, the American preacher; Lubbock, the English parliamentarian, and Maeterlinck, the Belgian novelist. Robert Bruce got inspiration from a spider, and engineers have studied with profit the architectural skill of insects and spiders, particularly with regard to bridge making. The study of bees offers much more than the mere output of commercial honey. These lower animals show the real natural state of society, and make ridiculous Rousseau's wild imaginings. They have their trades, their agriculture and animal breeding, their guests and slaves, even their tools; they construct an eminently appropriate architecture with no waste of material, they store food and keep their cities clean and aseptic; some show even the beginnings of barter and exchange. Most of these occupations we generally suppose to be limited to ourselves, for we are nothing if not egotistic. The wonder of it is the perfect order and harmony, the excellence of the state. Willoughby was undoubtedly wrong in arguing that the state exists only in the case of man. Now, can sociology afford to disregard such data? Can the conflicting factors of human society be explained only by the study of man? Surely we ought to at least wrest from the insects their secret of perfect harmony. Many of man's occupations extend far back into nature, therefore to understand them we must trace them to the community life of lower animals, even back of this to the origin of the factor that made the family, the maternal instinct. Sociology has applied some of the teachings of pure science, such as the operation of selection and the struggle for existence. But if it is to have a scientific foundation it must base itself on the comparative study of community life.

I do not mean that the study of an ant family will give us any better system of taxation. But I do mean that the careful study of lower social states will lay a firmer basis to the general subject of sociology, and thus come to better human conditions. Then also our treatment of criminals must to large extent rest upon biology, for the main practical question involved is whether criminal traits and tendencies are inherited or whether they are learned. The whole subject of heredity is a biological one, and the outsiders who have ventured into this field have given no solutions. How we shall treat criminals and their children will depend upon the outcome of the theoretical investigation of heredity.

Much more might be said concerning the practical value of pure science, but I will mention only one more point, and that right briefly. It is ethical and is perhaps the most important of all. Science seeks the truth, and respects no opinion that does not represent the truth. Science is not so much materialistic as realistic, and it has to do only with what may be determined by experiment and observation. Like the every-day practical man, the scientist holds that those things that seem outside of himself are really outside, and not existent simply in his own mind; and he is striving to explain the relation of those things to each other and to himself. While confining himself to such subjects he does not, in fact, has no right to, imply that there are not other fields of thought. But with regard to the world of things, he claims the right to decide what is real and what is unreal. That man is valued the most in science who sees the truth most clearly, and states it most simply. Right or wrong in science is then a measure of the truth. The great outcome of scientific thought is the unity of all nature, and the great aim in view is the truth. Thoughts like these must come to profoundly modify systems of ethics. Science has a difficult road to travel, for it keeps pushing steadily onward into dark places. In the nature of the case it must make many mistakes, but it keeps the right ideal. The idea of the truth and the ways of reaching it may continue to change as they have in the past, but humanity can not go far wrong so long as it earnestly seeks the truth.

These matters are worth thinking about when there is so much discussion about the value of higher education. We hear protests against the cost of maintaining universities, and there are some people who honestly suppose that the higher seats of learning should be self-supporting. Indeed there was one college started in the east by a millionaire, and he was greatly surprised to find that he was to get no dividends. Education is never satisfied; it uses greedily all available funds, then calls for more. If an institution does not receive an increasing amount each year, it is not only standing still, but it is also going backward, for it gets more and more behind the times. Practical men are quite right in inquiring whether there is going to be some return to them out of this expenditure, and we have to answer them truthfully. Universities and museums and libraries, the centers of scientific activity, have enormous mouths that are always agape, like overgrown nestling birds. You put money into them, but you do not get money back, at least not directly. This point is very certain and there is no use trying to hide it. But what you do get back are ideas, new ideas. Much of the work represented by such institutions is scientific, and if you endow them you help to increase the ideas that make possible practical ends. You will notice that I have not been arguing for the prosecution of applied science, more properly, the applications of science, for the value of this is apparent to all. I have been speaking for the pursuit of pure science, because it is the necessary forerunner to any new practical application. This is the fact I wish to drive home because it is seldom understood. Scientists themselves often do not realize it, but think that pure science should be studied, even if it can never be made to touch the needs of human life. Men who are not scientists are apt to shrug their shoulders and to say that science may be interesting to some, but that they can not see the use of it and consequently can not see the value of education in pure science. So long as this remains the point of view, higher education and research must have the old hard road to travel. But if we will open our eyes to the fact that even pure science is really of useful value, and its history is proof of this, then the standing objection to higher education will be removed.

THE PHYSIQUE OF SCHOLARS, ATHLETES AND THE AVERAGE STUDENT

By Professor D. A. SARGENT
HARVARD UNIVERSITY

IN the year 1893 Dr. W. T. Porter, now professor of comparative physiology in the Harvard Medical School, examined some 30,000 children who were attending the public schools of St. Louis, Mo. He found that among pupils of the same age, ranging from 6 to 18 years, the average height and weight of those who were in the higher grades were greater than that of those who were in the lower grades. In other words he found that those pupils who were mentally the most precocious were also physically the most precocious. This announcement called forth considerable criticism at the time, and many teachers, recalling a number of exceptionally bright pupils who were small in stature for their age, doubted the truth of the statement. It is of great scientific interest, therefore, to note that Porter's conclusions have since been confirmed by observations made by Hastings in Omaha, Nebr., by Byer in Cambridge, Christopher in Chicago, Roberts in London, Burgerstein in Vienna and by Leharzig in St. Petersburg. In the face of such a body of concurrent statistics from different parts of this country and Europe, no one can doubt for a moment the natural relationship between a vigorous brain and a vigorous body. Moreover this intimate relationship between body and mind does not appear to be limited to growing youth as shown by the statistics to which I have just referred, but it is true of all classes of individuals when taken collectively. For instance the fellows of the Royal Society of England and the English professional class, who may be said to represent the greatest brain power of the British Empire, average respectively 5 feet 9¾ inches and 5 feet 9¼ inches in height and 160 pounds in weight; while lunatics, criminals, idiots and imbeciles who may be said to represent the other end of the intellectual scale, if they are not classed as mentally defective, average in height from 5 feet 7 inches to 5 feet 4.87 inches, and average in weight from 147 pounds to 123 pounds. Here is a difference of 4.88 inches in average height and 37 pounds in average weight between the highest and lowest classes of English society as represented by members of the Royal Society and idiots and imbeciles. Compared with the general population, lunatics according to Roberts show a deficiency of stature of 1.96 inches and of weight 10.3 pounds; and criminals of 2.06 inches and 17.8 pounds, indicating a deficiency of physical as well as mental stamina in both these unfortunate classes of society.

The physical measurements of the English and American people are so nearly identical, as shown by comparisons which I made with Mr. Galton's measurements some years ago, that conditions that affect one class of persons in England may be said to affect in a similar way the same class of persons in this country. We have already seen that growing youth in different parts of this country and Europe develop mentally as they develop physically, and that the men who have attained the highest degree of intellectual eminence as a class, have invariably had a good physique as shown by their superior height and weight, to back up their superior intellectual vigor. In view of these indisputable facts we should expect to find that the same observations would hold true among college students, who may be said to represent the intermediate class on the way from growing youth to men of intellectual eminence and distinction. According to our physiological law we should expect to find that the students as a class who ranked the highest in scholarship would also have the best physiques, as shown by their superior height and weight. In order to ascertain if this inference be true, I have had the following table compiled from my statistics at Harvard University, from which some very interesting and instructive conclusions may be drawn.

Group	No. of Observ.	Groups on which Observations were Made	Height		Weight		Strength
			C'm.	In.	K'l.	Lbs.	
1	240	University Crew from 1880 to 1900	177.5	69.9	69	152.1	625
2	295	University Football from 1880 to 1900	176.5	69.5	71.5	157.6	652
3	505	Lawrence Scientific School from 1902 to 1906	174.5	68.7	65	143.3	680
4	530	Academic Department from 1904 to 1906	174.5	68.7	63.5	140	650
5	300	First Fifty Strong Men from 1893 to 1900	174	68.5	68.5	151	960
6	77	Honor Scholarship Men, Group I., 1899 to 1906	174	68.5	61	134.5	550
7	300	Honor Scholarship Men, Groups I. & II., '99 to '06	173.5	68.3	61.5	135.6	550
8	232	Honor Scholarship Men, Group II., 1899 to 1906	173	68.1	61.5	135.6	560
9	84	Stipend Scholarship Men, Group III., '99 to '06	172.5	67.9	61.5	135.6	560
10	500000	Average American in 1860 (Army Standard)	172	67.7	61.7	136.05	
11	1000	University Students in 1880	172	67.7	61.3	135.2	490
12	106	Stipend Scholarship Men, Group I., 1899 to 1906	172	67.7	59	130.1	530
13	109	Stipend Scholarship Men in early eighties	171.5	67.5	60	132.3	420
14	431	Stipend Scholarship Men, Groups I., II., III.	171.5	67.5	59.5	131.2	540
15	178	Stipend Scholarship Men, Group II., '99 to '06	170.5	67.1	59	130.1	530

This table consists of the medium measurements of 15 different groups of men, all except Group 10 being composed of students of Harvard University ranging in age from 18 to 26 years. These groups are arranged according to superiority in height and weight. Group No. 1 consists of 240 university crew men, the number whose measurements have been taken since 1880 to 1906. The medium height is seen to be 69.9 inches and the medium weight 152 pounds. Group 2 consists of 295 university football men examined since 1880. The mean height of this group is 69.5 inches, and the mean weight 157.6 pounds. Both the crew and the football groups are composed of picked or selected men, the former being chosen largely for superior height and the latter for superior weight. It will be observed that the strength of both of these groups being 625 and 652, respectively, is lower than some of the groups that follow. The reason for this difference may be explained by stating that prior to 1890 there was no required strength test, and the great majority of the crew and football men in the eighties fell below the present requirement for university athletes, which is 700 points. Group 3 is composed of 505 students who entered the Lawrence Scientific School during the years 1902–6. The height is 68.7 inches, the weight 143.3 pounds, and the strength 680 points. Group 4 is composed of 530 students who entered the academic department during the years 1904–6. The height is 68.7 inches, the same as that of the Scientific School men, but the weight is 140 pounds, or 3.3 pounds less, while the strength is 650, or 30 points less than the Scientific School men. These two groups, comprising some 1,035 undergraduates, are made up of all classes—of athletes, scholarship men, semi-invalids and average students—as they come to the university from the preparatory schools. The Scientific School students are heavier and stronger than the academic students, a fact frequently referred to by the late Professor Shaler, showing his remarkable powers of observation. The most significant facts in regard to these two groups can only be comprehended when they are compared with Group No. 11, comprising 1,000 students taken from the four classes and all departments of the university in 1880. It will be observed that in 1880 the medium height of the university student was only 67.7 inches, although the group contained many men who had been in college three and four years. The medium weight of this group was 135.2 pounds and the total strength 490 points. The average weight and height of the Harvard student at this time was about the same as that given for the American youth, ranging from 21 to 26 years of age, who entered the army in 1860. At the present time the average student is an inch taller, and from 4 to 8 pounds heavier than the average student of 1880, while his strength has increased from 490 to 650 and 680, a gain of 140 and 190 points. In 1880 only 50 per cent. of the Harvard students would have surpassed the height and weight of the army average. To-day over 65 per cent. would pass that standard. This is a most remarkable uplift in growth and development for any considerable body of men in any country or community to have attained in 25 years. My only hesitation in accepting this fact as conclusive is the lingering doubt as to what effect the 30 or 40 per cent. of students who are never weighed or measured at the gymnasium might have upon the medium height and weight. The 1,035 men examined from the Academic Department and Scientific School, as I have stated, comprised all classes, including the short as well as the tall and the weak as well as the strong, and may, therefore, be regarded as fairly representative of the physique of the college.

It may surprise many to learn that the strongest men in college as a class are below the average student in stature. This is perfectly consistent with established facts. Strength is more a matter of shortness and thickness of arms and legs than of great length of limbs, which is likely to be the physical characteristic of speed, as shown by runners and oarsmen, rather than strength and endurance. The superior musculature of the strong man is indicated by his superior weight. In this respect it is observed that he weighs from 7 to 10 pounds more than the average student, while he surpasses this man in strength by some 300 points.

Having ascertained the medium height and weight of what we have termed the average student, let us turn our attention to the same measurements of scholarship men. It is interesting and instructive to observe that the scholarship men when taken in large groups tend to verify the conclusions reached by Drs. Porter, Byer, Christopher, Roberts, Leharzig and others as to the correlation of a superior mind with a superior body. This is shown rather strikingly by the order in which the scholarship men group themselves according to height, the highest scholars in Group I. being tallest, those in Group II. being nearly one half inch shorter. The scholarships in Group III. are not awarded according to college rank, but for some other special consideration. Although the order among the scholarship men themselves remains the same, that is, the highest scholars as represented by Group I. being the tallest, Group II. over one half inch shorter, etc., the great discrepancy between the height of the honor scholarship men, the stipend scholarship men, and the average student seems at once inconsistent with our premises. Although the honor scholarship men have risen nearly three quarters of an inch in height above the average university student of 1880, the average stipend scholarship men as shown in Group 14 (I., II. and III.) are about one quarter of an inch shorter. There is a difference of 1.2 inch between the height of the average student of to-day and the average stipend scholarship men, and a difference of three quarters of an inch between the average stipend scholarship men and the average honor scholarship men. The discrepancy between the average weight of the different groups is not so regular or well marked as that of the height, although it will be observed that there is a difference of 4.4 pounds between the average student and the honor scholarship men and a difference of 8.8 between the average student and the stipend scholarship men.

The comparison of strength between the average student and the scholarship men is rather more favorable to the latter. Although there is some 100 points difference in the tests of Groups 3, 4, and 7 and 14, all the groups of scholarship men have surpassed the strength test of the average university student of 1880. The height and weight of the student within normal limits may be said to represent his potential strength and vital capacity. The actual test of strength gauges his real functional power—or would so gauge it if each student tried to do the best he could. While the required physical test for athletes and scholarship men has undoubtedly stimulated many students to make greater physical efforts in preparation for the examination, it has made many of them simply content in doing just about enough to pass the minimum requirement. This in a measure accounts for the more uniform tests of the scholarship men, and the little difference between Groups I., II. and III. The average student, as shown in Groups 3 and 4 is more likely to try to make a good strength test than the scholarship men, as he is desirous of passing the minimal requirement for the athletic teams, in order to be eligible to one or more of these organizations. Although the average height and weight of all the scholarship men are below the average student of to-day, the average of the honor scholarship men is considerably above the average of the university students of 1880—while the average of the stipend scholarship men of the present time is not only below the average students of that year in point of weight, but is below the average of the stipend men of the early eighties. Although the number of men in Groups 6 and 9 is rather small to base definite conclusions upon, the numbers in the other groups are large enough to give conclusive evidence of the trend of physical development in the three great classes of Harvard students, namely, the scholars, athletes and the average students. The discrepancy in the physical measurements of the several groups of scholarship men and the average students raises questions which are in my opinion worthy of grave consideration. The physical superiority of Group I. over Group II. in point of height among both the honor and stipend class of scholarship men is perfectly consistent with acknowledged physiological truths in regard to mental and physical development. But the dominating factors that determine stature and weight are age, race and nurture. The medium or average age of Group I. of stipend scholarship men is 19 years, of Group II. 20 years, of Group III. 19 years and 3 months, and the Lawrence Scientific School Scholarship Group is 22 years. The average age of Groups I. and II. of the honor scholarship men is 18 years and 6 months, respectively. Here it will be noted that the honor scholarship men, though the youngest are the tallest, heaviest and strongest. Does the advanced age of the stipend men indicate inferior natural ability or retardation in mental and physical development due to preoccupation with other work? In either case the question also arises whether the stipend man's scholarship standing is not due to industry and patient application rather than to superior organic vigor.

In regard to race it is interesting to note that 77 per cent. of Group I. and 75 per cent. of Group II. of honor scholarship men were Americans, while only 62 and 71.5 per cent., respectively, of Groups I. and II. of stipend scholarship men were Americans. The Hebrew race had the next largest per cent., being 15.5 and 11 per cent. in the I. and II. honor scholarship class and 11.3 and 7.75 per cent., respectively, in the stipend scholarship class. But the English and Polish Hebrews, from whom the American Hebrews have largely descended, average only 66.5 inches and 63.8 inches, respectively, in height. The other races, all averaging below the Americans, except the English and Scotch, are represented by a very small per cent. in any of the groups, but the largest number of foreigners, from 30 to 40 per cent., is in the stipend scholarship class. In a measure, this fact would help account for the inferior stature of this class of students. The differences in height and weight, due to nurture in adults of the same age, sex and race, averages as high as 3½ inches in stature and 7 pounds in weight. The honor scholarship men are presumably better nurtured than the stipend scholarship men, coming as they do from wealthier families where they have been better housed, fed and clothed, and better cared for generally. The difference between the average of Group I. of honor men and Group II. of stipend men is 1.4 inches in height and 4.4 pounds in weight. This extreme difference is probably partly due to race inheritance, and partly due to nurture, but what may be termed the organic or physiological factor plays an equally important part. It will be observed that there is little variation in weight between the different groups of scholarship men, in the honor men Group I. actually weighing over a pound less than Group II., and the stipend men of Group I. only equal the weight of Group II.

It will also be noticed that there is a close correlation between the weight and the strength in the different groups. This diminutive weight upon the part of all scholarship men may be accounted for in several ways. The most reasonable explanations, however, are lack of sufficient physical exercise, and mental over-training. In order to meet the demands of the present scholarship standard it is necessary to hold oneself down to many hours of highly concentrated and long-sustained mental effort. Under these circumstances the respiration and circulation are slowed down, the digestion is more or less imperfect, and the organic activity of all parts of the body except the brain is sadly interfered with. The body for the time being is literally being starved in order that the brain may be surfeited. If this intense mental activity is followed by a moderate amount of physical exercise, in which the large masses of muscle in the trunk and limbs are vigorously used, no harm follows from hard study. In developing the muscular system one not only adds to girth of trunk and limbs, and consequently to weight as seen in the physical condition of the 300 strong men in Group 5, but increases the functional power of heart, lungs, stomach and viscera—and consequently favors the nutrition and recuperation of the brain itself. If to intense or prolonged mental application are added worry, anxiety, fear of failure, loss of sleep, or great emotional strain—then mental work soon becomes exhausting. Add to prolonged physical effort the same kind of mental and emotional harrassments, and we soon have in the individual or athletic team a temporary state of physical and mental impairment which is familiarly attributed to "over-training." No one symptom is more indicative of this approaching collapse than loss of weight, and on the other hand no physical sign presages a return to bodily and mental efficiency more unerringly than a return to normal weight. Normal weight for the average student is about 2.05 pounds for every inch in height, for the university crews 2.17 and for the football teams and strong men 2.20. The army standard during the civil war was 2 pounds to the inch for the soldier of medium height.

The Harvard scholarship men range in weight from 1.87 in the lowest group to 1.99 in the highest. These chronic conditions of underweight on the part of the scholarship men are, in my opinion, largely due to excessive mental activity, accompanied in many cases by nervous anxiety and perpetual worry for fear that they will not come up to the desired standard and fail to receive honors or lose their scholarship stipend. Judicious physical exercise, out-of-door games and recreations, mingled freely with innocent social amusements, all tend to relieve this state of nervous tension and malnutrition, as many a hard-worked student knows from experience. The physical superiority of the honor scholarship men over the stipend scholarship men may be largely attributed to the fact that they do devote more time and attention to the care of their physique. When the stipend scholarship men are asked why they do not give more attention to their health and the upbuilding of their bodies, the almost invariable answer is: "We have no time for it," or words to that effect. In many cases this is literally true, as there are scholarship men at Harvard who have to do a considerable amount of outside work in addition to their college work in order to earn money enough to meet their expenses. But in the great majority of cases the answer of "no time" means that these men do not regard health and physical vigor of sufficient importance to work for it; or if they do, they fear that while they are taking time for improving their bodies, their nearest rivals are at the everlasting grind that will give them possession of the much-coveted scholarships. Some of the results are shown in the table to which we have referred. Here is an anomalous condition.

According to our records the physique of athletes and the average student during the past 25 years has greatly improved, while the physique of all the scholarship men of to-day is not only below the average student of the present time, but the physique of the stipend scholarship men is actually below that of the average student of 1880, and Group II. below the average of the stipend men in the early eighties. As the records we have quoted give for the most part the first-year measurements and tests of the students, they may be said to reflect the conditions that have acted upon them at their homes and preparatory schools rather than at the college. These formative influences, whatever they may have been, have affected the scholarship men as well as the athletes, but in a different way. The great interest that has been awakened during the past quarter century in health, hygiene, sanitation and physical education has begun to make itself felt throughout the country at large, and students are coming to the college now in better physical condition than ever before. This improved physical well-being has undoubtedly been greatly intensified by the time and attention given to athletics in the preparatory schools. The public interest awakened and the extensive advertising that athletes have received through the press have fired a considerable portion of our youth with an ambition to become large, strong and athletic. On the other hand, the intense mental and nervous activity of the age, the universal demand for a higher and broader intelligence, the great rewards for professional knowledge and skill, the prestige and traditions of the institutions of learning, have all combined to stimulate another set of our youth to great mental efforts. If athletics advertise the college, as so many persons affirm, they will tend to draw to its halls the young men who are fond of participating in athletic sports or of witnessing the athletic performances of others. Young men of a more studious frame of mind, who care little about athletics, would be attracted by the reputation of the individual professors, the academic standing of the institution, and the eminence of the positions held by its graduates.

It is very evident that a process of selection has been going on in the community during the past half century by which these two distinct types of young men, whom we may term scholars and athletes, have been attracted to the colleges and universities. Is this process of selection a natural one, or such a one as should exist in an institution of learning? Both classes have ideals and aims which are essentially different. Both classes are naturally antagonistic, and both classes are pursuing the means of education and training as though they were ends in themselves. The consequence is superior physiques with mediocre mental ability according to the college rank-book in one class, and inferior physiques with fine mental attainments in the other. Moreover, this want of harmony or sense of proportion between mental and physical efforts on the part of our students, which we all recognize, is greatly intensified by that crying evil of the age, the spirit of competition. Competition is to-day the arch enemy of all true culture, mental as well as physical. To recount all of the evils that may be attributed to this factor in education would prolong this article to an unwarrantable length. Let me return, therefore, to my premises.

If there is any truth in statistics the world's work and greatest achievements are to be attained by the men as a class who have the best brains in the best bodies. A large part of the athletic class will fail in the race of life for want of better trained minds, while an equally large class of scholarship men will be eliminated from the struggle for the want of more efficient bodies. What is the college doing to even up the chances of these two classes in their preparation for their life's work? She insists upon a required mental examination of all students, athletes included, upon entering college. Moreover, most colleges now require athletic students to attain a certain grade in their mental pursuits before they can be permitted to contend for honors in athletics. Would it not be altogether desirable for these colleges to require all scholarship men to attain a certain standard in their physical work before allowing them to compete for honors in scholarship? Such a plan would at least put the scholarly man on an equal footing with the athlete and give him a chance to attain something of that mental force, physical vigor and sustained energy upon which his success in life will so largely depend. Furthermore, inasmuch as the greatest amount of physical as well as mental improvement of which the individual is capable must take place during the formative period of his youth—should not the student come to college prepared physically as well as mentally for the ordeal before him? The moral effect of a physical requirement would be to throw the responsibility for physical condition back upon the parent, the preparatory schools and teachers, as well as upon the pupil himself. In my opinion a large part of the community is already prepared to meet this responsibility, as is indicated by the improved physical condition of the average student when he enters college. We have already shown that love of sports, games and physical exercise for themselves do not appeal to the scholarship student. The thing necessary is academic recognition of good health and physical vigor as an asset in education. In taking this step the college would simply be making a practical application of its own teaching. But in so doing it would not only improve the physique of the scholarship man, and thus increase his respect for physical training and athletics, but it would also increase the respect of the mass of students for scholarship men and scholarly attainments.

MODERN AND EARLY WORK UPON THE QUESTION OF ROOT EXCRETIONS

BY HOWARD S. REED

BUREAU OF SOILS U. S DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

AFTER the lapse of over half a century the one-time well-known theory of De Candolle has again come into prominence. The demonstration that De Candolle was essentially correct in his deductions revives interest in a phase of plant physiology which has been comparatively unnoticed for many years. In brief, his theory was that plants excrete from their roots substances which are deleterious to continued growth. These excreted substances were believed to have a deleterious effect when absorbed from the soil by other plants belonging to the same order as the plants from which the excretions came, but according to the De Candollian theory the excretions would be harmless or even beneficial to plants belonging to a different order.

Although this theory was supported by numerous botanists and chemists of the last century, it has come to be known in the literature as "De Candolle's theory of root excretions." There is obviously a twofold reason for this: first of all, the prominence of the man himself in his own and subsequent times and, secondly, the fact that he used this theory to explain the well-known benefits of crop rotation in agriculture.

Before the work of De Candolle appeared, Brugmans had alleged that he observed drops of liquid to exude from the roots of *Viola arvensis* and that he had observed small fragments of material at the extremities of the roots of certain other plants which he regarded as excretions. Although his observations were made without the precautions necessary for scientific experiment, they appear to have been quite widely accepted by naturalists of the time, among them such men as von Humboldt and De Candolle. To these pioneer workers the idea that there may be noxious substances present in the soil appeared to be the most direct means of explaining many pertinent problems of plant distribution and of agriculture.

De Candolle carried his idea further and used it to explain the apparent antagonisms of certain plants and expressed his belief that they injured their neighbors by the substances exuded from their roots into the soil. He cited the case of the cockscomb, which, he said, appears to have a bad effect upon neighboring vegetation, and euphorbias, which are harmful to the growth of flax, tares to wheat, and thistles to oats.

One of De Candolle's contemporaries, Macaire-Prinsep, carried out some experiments, which for a time gave promise of firmly establishing the existence of plant (or root) excretions. Macaire-Prinsep took up a number of adolescent plants and after carefully washing their roots, placed them in vessels containing rain water. He reported that after eight days the water in which healthy specimens of *Chondrilla* had grown had acquired a yellow tint and a strong odor. The water had a bitter taste and gave a precipitate when added to solutions of lead acetate. The same investigator also reported that water containing the excretions from the roots of peas was fatal to other plants of the same species, but not to wheat plants.

Using these ideas and experiments as a basis, De Candolle formulated a theory to account for the well-known benefits of crop rotation. He expressed a belief that the harmful effects observed when the soil is continuously cropped with the same species are due to an accumulation of noxious excretions. According to his theory, the substances excreted by the roots of one order of plants were not usually harmful to the roots of plants belonging to other natural orders; in fact, they might be slightly beneficial. In support of this idea he cited the incontrovertible observation of every husbandman that in the majority of cases good yields of all crops are obtained from the soil when plants belonging to different natural orders are grown in succession.

De Candolle pointed out that there exist, in a state of nature, natural successions of forest trees in the course of which a given species of tree is completely replaced by another species. According to his observations the first species seemed to disappear because its excretions so filled the soil as to render it unsuitable for the longer growth of that species. It is interesting to note in passing that he published an article in the *Revue française* showing the harm wrought by the decree of Louis XIV. that forests should be perpetually maintained upon forested lands.

De Candolle also made the trenchant observation that when shade trees die from any cause it is very difficult to replace them with trees of the same species.

Using these observations as a foundation, he built up a theory that plants may injure each other by the matter excreted from their roots, and that the success of crop rotation lies in preventing an undue accumulation of excreted material in the soil. He went further and expressed his belief that the excretory matter of the plants of certain families, like the legumes, is not only feebly toxic to themselves, but possesses actual value as a fertilizer for the cereals.

The ideas and observations of De Candolle were not allowed to pass unchallenged, for within a few years controversial articles began to appear.

Unger, and his pupil, Walser, showed that there had been certain flaws in the work of Macaire-Prinsep and made objections to his results. Walser believed that, if Macaire's statements were correct, it would be possible to demonstrate the presence of organic material in the soil similar in composition to that existing within the plants which had grown upon it. Braconnot, making the same assumption, attempted to demonstrate the existence of opium-like bodies by washing the soil on which plants of the poppy family had been grown for several years. He obtained a solution of inorganic compounds, and, in addition, only traces of organic compounds, and concluded that "If organic excretions really take place in the natural state of the plant, they are, as yet, so obscure and so little known as to justify the assumption that some other explanation must be given for the general system of rotation." Working without the proper idea of the difficulties of such a task and without adequate knowledge of the organic compounds in the soil, it is little wonder that they failed to demonstrate the presence of compounds in the soil which might be regarded as excretory matter from plants. They deserve credit, however, for showing that Brugmans had entirely misinterpreted the death of the root-hairs and the decortication of the growing roots and had assumed that this material was solid excretory matter from the living root.

One of the most scientific attempts to study this question appears to have been made by Alfred Gyde, the results of whose work were published in 1846 in the *Transactions* of the Highland and Agricultural Society of Scotland, and which won for the author a premium of twenty sovereigns. His *modus operandi* was to raise plants in pots of garden soil, sand, moss or charcoal; to remove them at different times; carefully wash their roots free from all adherent material and place the root systems in vessels of distilled water. After a certain length of time had elapsed, the composition of the water in the various vessels was studied.

Mr. Gyde reported that the roots imparted to the water soluble substances, to be regarded as excretory material, and that these excretions seemed to be yielded in greater abundance by plants having coarse roots like beans than by those which had finer roots, like wheat. In some instances the water acquired an odor which was separable on the application of heat and could be distilled over when the water was placed in a retort. Plants like the bean and cabbage imparted an odor to the water similar to that which characterizes their leaves. Plants when in bloom were observed to emit more excretory material than when young or when ripening their seed; but in any case the amount of excretion obtained after evaporating the water was very small. When this small amount of organic matter was reapplied to the soil in which other plants were growing, no harmful effects were observed. Without appreciating the additional factors which would have to be considered in such an experiment, *e. g.*, absorptive power of the soil, action of microorganisms, oxidation, etc., Mr. Gyde concluded that the excretions of plants are not harmful to their kind, but that the necessity for a rotation of crops arises from the depletion of the soil of the mineral plant food constituents. He thus appears to turn, *mirabile dictu*, from a proposition which was partially proved to one for which he had no proof; neither has conclusive proof been afforded by any subsequent investigator.

Professor Johnson in "How Crops Grow" has justly remarked that Mr. Gyde's results are not to be regarded as conclusive proofs for or against the existence of root excretions.

The curiously regular growth of fungi in continually widening circles, known as "fairy rings," presents many questions of scientific interest and it is not surprising to find that the theory of deleterious excretions was called in to explain this phenomenon. If one assumes that harmful excretions are left in the soil by these plants, it is easy to understand how the new and thrifty growth would continually arise on the outer edge of the ring, and thus give rise to the phenomenon observed.

The subject of "fairy rings" appears to have been studied by Way, who admitted, in a paper published in 1847, "that by far the most scientific and intelligent solution of the question is that which was based upon De Candolle's theory of the excretions of plants." But on account of objections which appeared insuperable to him, he was unable to accept it as a final satisfactory explanation.

In connection with the decadence of the De Candollian theory, special mention must be made of Liebig and of his attitude toward the question. At first he pronounced this theory of crop rotation to be the only one "resting on a firm basis." He regarded the experiment of Macaire-Prinsep as positive proof that the roots, probably of all plants, expel substances which can not be utilized in metabolism.

In addition to his extensive investigations upon the chemistry of the soil, Liebig made numerous studies upon the chemistry of the ash constituents of plants. He found that the essential elements were present in the ash of all plants, in quantities which formed a more or less definite ratio for a given plant. Reasoning from these facts, Liebig developed the idea that each plant requires a certain ratio of mineral constituents in the soil, as well as a certain minimum amount. He held firmly to the idea that plants could no more attain their maximum growth in the absence of a proper ratio of these mineral nutrients than when the total quantity was too small. This theory became known as Liebig' theory of mineral requirements.

Liebig's explanation of the benefits of crop rotation followed as a corollary to his theory of mineral requirements; since plants take their essential constituents in such established ratios they must in time destroy the necessary ratio of these elements in the soil, but when another plant drawing its ash constituents in a different ratio is substituted, it obtains a sufficient supply of nutrients and the soil is thus relieved of exhaustion.

Under the domination of Liebig's theory of mineral requirements, the theory of De Candolle was practically abandoned. Subsequent to his time the mineral matter of both soil and plant claimed paramount attention, and the biological factors connected with soil problems were almost entirely neglected. Unscientific as it now appears, it must be admitted that for several decades Liebig's dictum had more weight than any amount of experimental evidence. It would even appear that his word has been regarded so infallible in certain quarters that further scientific research has been regarded as unnecessary.

The inadequacy of the theory of mineral requirements alone to explain the productivity of soils has been aptly set forth by Coleman in an essay "On the Causes of Fertility or Barrenness of Soils," presented to the Royal Agricultural Society of England. This essay, although written fifty years ago, expresses the status of the problems of the mineral requirements theory as well now as at the time it was written. He says:

> The causes which operate in producing the fertility or barrenness of soils have hitherto to a great extent been shrouded in mystery, not from any want of study, but owing to the difficulties which meet the inquirer at every step, and the fact that most important results frequently depend upon causes which have eluded the search of the experimenter. The science of chemistry it was hoped would afford the key wherewith to unlock the mysteries of nature, but though its discoveries have conferred much practical benefit on the agriculturist, it has up to a very recent period effected comparatively little toward settling the causes of fertility or sterility. The theories of scientific men led us to expect that fertility depended upon the presence of certain mineral substances which were found invariably present in the ashes of plants, and the analysis of a soil it was believed would confirm the practical experience of the farmer; these hopes have been falsified except in the few cases of almost simple soils, such as pure clays and sands. In all other instances the analysis presented the existence in varying proportions of those substances supposed to induce fertility equally in the barren as the fertile soil. The proportion of the various ingredients was next proposed as a sign of quality, but researches into the amount of inorganic matter abstracted by each crop have demonstrated that soils of a mixed character contain abundant supplies of mineral food for numerous crops.

From the time of Liebig and the establishment of his theory of the mineral requirements of plants, there appears to have been no serious discussion of the subject of root excretion until recent years. The reports of the Woburn Experimental Fruit Farm of the Royal

Agricultural Society of England for the past few years contain a series of significant articles by the Duke of Bedford and Dr. Pickering upon the mutual effect of plants upon each other. These authors observed that the growth of young apple and pear trees was severely retarded when grass was allowed to grow about their roots. The harmful effects were much more pronounced in the case of grass than in the case of weeds. Young trees planted in a pasture, with all the sod replaced around them, died during the first season, but when a small circle of sod was permanently removed, they lived. The first supposition was that the injury was due to the removal of plant nutrients, and experiments were accordingly inaugurated to ascertain whether this was the case, but all the experiments answered the question in the negative. Experiments were also conducted to determine whether the removal of water by the grass was the cause of the injury, but again a negative answer was obtained. The results of other experiments showed that the injury could not be ascribed to the presence of an excessive amount of carbon dioxide, or to the lack of oxygen, since the characteristic injury was only observed when grass was growing around the tree roots. The authors finally concluded that the injurious effect of the grass could be due only to some action on the tree roots akin to that of direct poisoning, leaving the question open as to whether this action is due to excretions from the grass or to the changed bacterial action in the soil induced by the presence of grass.

Jones and Morse, of the Vermont Agricultural Experiment Station, have reported observations which indicate that a somewhat similar antagonism exists between butternut trees and the shrubby cinquefoil. They found that the cinquefoil, which grows abundantly in certain localities, was not found under or around butternut trees on a circle fully twice the diameter of the tree-top. Their observations showed that the "dead line" for the cinquefoil is pushed outward year by year as the butternut tree expands, so that the trees may be surrounded by a circle of dead and dying cinquefoil plants bordering the clean grass plot under the tree. Upon closer examination the roots of dead and dying cinquefoil plants were found always to be in close proximity to those of the butternut trees. That the injury was not due to shade or the removal of water is very improbable, since other species of deciduous trees in the same locality were closely surrounded by cinquefoil plants.

The antagonistic effect of roots is also shown by an instructive experiment recently published by Hunt and Cates in a bulletin of the Cornell Agricultural Experiment Station: Rectangular boxes of soil were planted with corn in one end and with common weeds in the opposite end. Where the roots of the two kinds of plants were allowed to intermingle, the corn made less growth than where a partition in the middle of the boxes kept the roots of the weeds separate from those of the corn. When the partition was present, each sort of plant was confined to half the soil in the box, but, where lacking, one sort of roots appeared to exercise a noxious influence upon the other.

In studying the general question of soil fertility, the laboratories of the Bureau of Soils in the United States Department of Agriculture have obtained some instructive evidence bearing upon this problem of plant excretions. The data obtained from different lines of experimentation all go to prove the truth of the general assumption that plants do excrete substances which may have a toxic action on the species of plants producing them.

The Bureau of Soils has recently published the outcome of some experiments in which several sets of wheat plants were grown in rapid succession on the same soil. The soil was kept in pots and each set of wheat plants was smaller than the one immediately preceding, as might have been predicted, since it is well known that the continuous culture of a given crop on a soil "exhausts" it more rapidly than the culture of diversified crops. In the experiments cited, the growth of the fourth set of plants was in some cases only 30 per cent. of the growth of the first set.

Such cases of apparent exhaustion have generally been assumed to be due to the removal of plant nutrients from the soil by previous crops. Accordingly, experiments were made in which mineral plant nutrients in the form of pure chemicals were added to the soil at the time of planting the successive crops in amounts equal or greater than those removed by the preceding crop. The addition of these supplies of plant food constituents failed, however, to produce a growth of plants equal to the first crop, although they helped the growth of the plants. This possibility of soil exhaustion is still further rendered improbable by the fact that the wheat plants grew only three weeks and during that time they derived much of their food supply from the reserve nutrients stored in the seed; hence the amounts taken from the soil were very small.

To emphasize the action of root excretions upon the soil, experiments were made in which the first set of wheat plants was allowed to grow for only five days, or until the plumules were just beginning to appear above the surface of the soil in the pots, a length of time obviously insufficient to "exhaust" the soil. All the plants were carefully removed and the soil again planted with wheat, simultaneously with the same number of pots of fresh soil. The plants following the five-day crop made only 80 per cent. of the growth of the plants in fresh soil.

The outcome of these experiments is quite strong proof that the cause of these decreased yields is not the depletion of mineral nutrients, but lies rather in the production of unfavorable soil conditions by the excretion of substances from the roots of preceding crops of plants.

The effect of root excretions is strikingly shown by some experiments in which wheat was grown in pure quartz sand. The sand contained a very insignificant amount of plant nutrients, but the young wheat seedlings were able to draw sufficient nourishment from the seed to maintain growth during the time of the experiment. Pots of fresh quartz sand were planted with wheat simultaneously with an equal number of pots containing quartz sand which had previously grown wheat for twenty-one days. The growth of the wheat in the "exhausted" sand was only about 45 per cent. of that in the fresh sand, in spite of the fact that both sets of plants were supplied with nutrients from the seeds. It would be obviously incorrect to ascribe the "exhaustion" of the sand to a depletion of plant nutrients at the outset. The harmful effects following a previous crop appear to be more probably due to the presence of deleterious substances arising in the sand during the growth of that crop.

Evidence from another experiment showed that the roots leave substances in the soil which may be removed by proper treatment. Three crops of wheat seedlings were grown in pots and showed decreasing yields. When the last crop was removed, an aqueous extract of the soil was prepared and used as a nutrient solution in which a fourth set of wheat plants was grown. A portion of the soil extract was shaken with carbon black, which acts as a strong absorbing agent, and filtered free from carbon black at the end of a half hour. When a soil extract possessing deleterious properties is given this treatment with an absorbing agent, it is almost invariably improved, on account of the removal of the harmful substances. In this "exhausted" soil the same results of the carbon black treatment were noticed as in the case of deleterious soil extracts. The extract of the "exhausted" soil produced as good plants, after treatment with carbon black, as the extract of fresh soil treated in the same way.

The antagonistic action of one plant upon another was shown by the harmful effect of trees upon wheat. Small trees were transplanted into paraffine wire pots and kept growing in a greenhouse where optimum conditions of light and moisture could be obtained. Wheat was also planted in each pot and allowed to grow about three weeks. As soon as the first set of wheat plants had been cut and weighed, a second set was planted and this was repeated at intervals of about three weeks, until nine successive crops had been grown, always growing control crops in pots without trees. The growth of the wheat in the pots containing trees was poorer than the controls during the summer while the trees were actively growing, but when autumn came and the trees entered their resting period, the growth of wheat in the pots became better. It does not seem possible that the harmful effects of the trees could have been due to the removal of plant food; if so, there would have been no increase in the yield in autumn. It seems, therefore, that the presence of the roots must have had some other effect upon the growth of the wheat, as the size of the pots made it necessary for the two kinds of roots to be in close physical relation. That the retarding effect is due to substances excreted by the tree roots seems probable. It was also noted that tree pots that produced as much wheat growth in November as the controls were the ones in which the trees showed the earliest signs of winter rest. These results seem to be conclusive, therefore, in showing that the injurious effect of the trees was due to the excretion of toxic substances from the roots.

These experiments, which may be regarded as furnishing negative evidence upon the problem, were supplemented by others which furnish more direct and conclusive evidence of a positive sort. By taking advantage of the chemotropic sensitiveness of the roots of seedlings, it is possible to employ them as indicators of the presence of their own harmful excretions. It is well known that roots, like other perceptive organs, will curve and grow towards substances possessing beneficial properties, but will curve away from other bodies possessing deleterious properties. Advantage was taken of this reaction to chemical stimuli for showing the presence of deleterious excretions.

Without going into lengthy details of the experiments in this place, it may be said that the method consisted essentially in growing roots in small glass tubes, from which they might escape at suitable openings if any stimulus caused them to turn aside from their normal downward course of growth. In this case there was a stimulus, and it was the deleterious matter excreted from the roots during growth. It was unmistakably shown that the growing roots of healthy plants do excrete deleterious substances in amounts sufficient to exercise an influence upon plant growth. It was shown that roots of wheat are indifferent to substances excreted by plants of another sort, like maize or cowpeas. The excretions from roots of a more closely related plant, like oats, were not as harmful to wheat as excretions from wheat, but more harmful than excretions from the more distantly related plants.

Recent work in the laboratories of the Bureau of Soils has resulted in obtaining organic compounds from "wheat-sick" and "cowpea-sick" soils. At the late meeting of the American Association for the Advancement of Science, held in Chicago, Schreiner and Sullivan reported the results of this work.

Wheat seedlings were grown continuously upon a soil until it became "wheat-sick," and its productiveness for wheat was quite small. This soil when carefully distilled yielded a small quantity of a crystalline organic compound which, when dissolved in pure water, exhibited a toxic action upon wheat plants, but was relatively *harmless to cowpeas.* Crystals were similarly obtained from a "cowpea-sick" soil and were found to be harmful to cowpeas, but relatively harmless to wheat plants. Since the same soil in which neither plant was grown yielded none of these substances, it seems only logical to conclude that these substances were formed as a result of the plant growth in that soil.

Data like those briefly presented above have given strong proof of the existence of excretions from the roots of plants, and show that they may exert a harmful effect upon the growth of succeeding crops of the same kind. Without too liberally interpreting these facts, it may be said that the demonstration of root excretions throws a new light upon the interrelation of soils and plants and promises to afford a solution to some important questions. De Candolle and his contemporaries failed to appreciate the agencies in the soil which effect the destruction of deleterious organic substances, and maintained that, once a crop had been grown, the soil would for a long time be unsuitable to that crop. When the majority of soils are kept in what is ordinarily known as "good tilth" by cultivation and continued rotation of crops, it is improbable that root excretions will accumulate to an extent which would be harmful. Processes of oxidation, brought about by proper cultivation, the oxidizing power of roots, and the action of micro-organisms in the soil are important factors in destroying these deleterious substances. It has also been shown that substances ordinarily employed as fertilizers have a destructive action upon toxic substances, especially when aided by the action of plant roots.

It is more than probable that the consideration of the existence of root excretions will also throw considerable light upon the problem of assóciation and migration of species and individuals in the vegetable kingdom. The reasons for the association of certain species in nature have often been studied, but never satisfactorily explained. The same applies to questions of migration and natural succession. It has been shown that such physical factors as light and water play important parts, but they have not been found sufficient to give a satisfactory explanation for all the phenomena.

It would seem that the methods of soil fertility investigations might be applied with profit to the study of plant ecology. The effect of the root excretions from one species upon another might in certain cases prove to be the controlling factor in association. From the evidence already at hand, it would seem that the biological factors play a definite and considerable rôle in these phenomena.

SILVER

By THEO. F. VAN WAGENEN, E.M.
DENVER, COLO.

PREVIOUS to 1870 silver was reckoned as one of the precious metals, and possessed, by virtue of an unwritten agreement between the principal nations of the world, a definite value in terms of gold, *viz.,* $1.29 per fine ounce. The metal was never purchasable at less than this figure, and usually commanded a premium, which, during the last century, ranged from nothing up to as high as ten per cent. It is now purely a commodity, like all the other metals except gold, and while the demand has greatly increased since the date just mentioned, the production has nearly quadrupled, and the price has fallen steadily until during last year it averaged 65 cents.

Curiously enough, since this great change silver has become one of the three metals (nickel and copper being the other two) that circulate as coins at a valuation far above their commodity price. This of course is due to the fact that they are by law legal tenders up to certain amounts, but the circumstance illustrates quite well the vagaries of human law when it comes into conflict with those of nature. The American quarter, the English shilling, the Latin Union franc, the German Mark, the Austrian Kroner, the Russian Rouble, all being coins that circulate freely at valuations ranging from twenty to twenty-five cents of our money, would bring, if melted and sold as bullion, little more than half those figures. On the other hand, the Indian rupee, of approximately the same weight and fineness, not being backed by any such law, circulates at its commodity value only, and its purchasing power in the markets of the world fluctuates with the price of the metal.

Silver sometimes occurs in nature in the metallic condition, and it is due to this fact that it has been known from very ancient times. But it is not found like gold, in grains or nuggets in the gravel of stream beds. Its principal habitat is the vein in rock, and hence it may be inferred that in antiquity the quantity possessed by man was much less than that of gold. To primitive man the latter metal was regarded, in a way, as a fragment, or at least a representative of the sun, while silver bore the same relation to the moon in his mind.

When the interior of China becomes well known, it is likely that the remains of very ancient silver mines will be found there, for the metal has been produced in that nation, in small quantities, from remote antiquity. There are no evidences that India ever possessed any silver mines of note, but in Burmah there have been found extensive slag dumps rich in lead and zinc, and carrying a notable per cent. of the white metal, whence it may be inferred that it was produced there in some quantity at some time in the past. In the little known and very rugged region between Hindustan, the Persian Gulf and the Caspian Sea, embracing the crude nationalities known as Persia, Armenia, Afghanistan and Baluchistan, there has been a small production ever since early historic times, and the same may be said of Asia Minor. The Grecian peninsula, however, possessed a silver-producing region of great importance and high antiquity, from which, as early as 1000 B.C., the metal came in notable quantity. There are no known ancient silver-producing districts of any note in Africa, but the Italian peninsula and Spain yielded the metal in early historic times, the former moderately and the latter very abundantly. In fact, Spain was really the first great silver-mining country of the world.

More than any other metal silver has been intimately associated with the advance of civilization, or rather of that very important department of human activity that is called commerce, meaning thereby international trade. Authentic history seems to begin with the fact of two comparatively peaceful, industrious and frugal races, occupying the rich valleys of the regions now called India and China; and a lot of turbulent, migratory people in western Asia, eastern Europe and northern Africa, who devoted much of their time and energy to fighting and destroying each others' homes. Between the two was the highest and most difficultly passable mountain chain in the world, known now as the Hindoo Koosh and Himalaya Range, which for centuries, and perhaps millenniums kept them apart effectively enough to allow each to develop its own peculiarities. The first, which we distinguish as the Orientals, appear to have settled down at a very early period to agricultural pursuits, and to such peaceful arts and occupations as were naturally the outgrowth of ruralism. Population grew fast, a crude and quiet, yet strong trading capacity developed, religious advance was marked, but was not of the proselyting kind, was more contemplative and introspective. The arts progressed only to a certain point, and then became stationary. Wealth was attained by industry and accumulation mainly, and did not often arise from exploration or conquest. Such luxury and ease as resulted never passed much beyond the barbaric stage. The sciences did not become exact or even organized, and have retained, up to the present day, an air of mysticism. Literature was of the contemplative kind, and produced only a most cumbersome methods of recording itself.

The second, which we may call the Occidentals, advanced along wholly different lines. Every department of life was more strenuous, and the results, naturally, were more notable. The increase of population was perhaps as great, but the destruction of life by wars and slavery was enormous. The arts flourished, especially architecture, but their product in the shape of buildings, highways, canals, libraries and museums was continually being looted by conquerors, yet this very ruthless destruction seems to have incited rather than discouraged advance and improvements. The sciences were developed up to the point where discovery began, literature to the stage, where it became imperishable because of the invention of comparatively simple methods of writing, society to a state where education was highly prized, religion to the conception of monotheism.

Between these two diverse and different kinds of humanity a trade slowly sprang into existence. It was first, doubtless, by way of the Arabian Sea, which at some time in the distant past was a "mare clausum," a Mediterranean, as the result of a land connection between east Africa and India, by way of Madagascar, the Seychelles and Andaman Islands; and later by caravan routes through the passes of the mountains. The western nations sought the luxurious and decorative products of the eastern, their fabrics of silk and wool, their manufactures of bronze, their gems and jewelry of ivory and jade. What could be given in exchange? It was early discovered that the money of the east was silver, that it was scarce there and its purchasing power great. Consequently when the strenuous west began to produce the metal in quantity, first from the mountains of Persia and Asia Minor, and later in Greece, Italy and Spain, it became possessed of an article with which the products of the east could be obtained. But the west loved war above all things, and had the warrior's immemorial contempt for trade, and so there gradually grew into existence, at the extreme eastern end of the Mediterranean, a nation of traders, the Phœnicians, who took charge of the commerce between the occident and the orient, who never gained any celebrity except along commercial lines, and who for centuries were actually protected in turn by all the great powers of antiquity because of their trading ability, and their knowledge of where and how to get those products of Asia that Europe wanted. We know that the ships of Tyre and Sidon ransacked the shores of the Mediterranean for silver, and were the owners and operators of mines of that metal in Greece, Italy and Spain. Their product was sent overland by caravan, or over sea by ships sailing from ports first on the Persian Gulf, and later on the Red Sea, to India, and exchanged for the manufactures of the east. One of the most valued of these was tin. Malaysia has been from the most remote antiquity, and is to-day, a prolific producer of this metal, and very early in the history of the human race the extremely desirable qualities of the alloy it made with copper (bronze) became known. For many centuries primitive Europe poured its silver into Asia and sold it for tin. In due time the demand became greater than the supply, and at the same time the product of the European silver mines began to fall off. The price of tin in terms of silver increased greatly. So also did the value of silver. In this crisis, which threatened the very existence of the trade between the east and the west, two remedies were tried. The Greeks, the dominant nation of the time, under Alexander the Great, started out to conquer India, and to find and capture the Asian tin mines, but, as we know, he never got any farther on the way than the valley of the Indus in eastern Hindustan, where he died. Simultaneously the Phœnicians began to search the western world for the metal, and finally found it in Britain. When Cornish tin began to come into the market, the corner that Asia had for so many centuries had on tin was broken, the Malaysian mines fell rapidly into decadence, and the ancient value of silver in the east was resumed. Europe then had the advantage, but as its silver product was on the decline, its trade with India fell away, and the two far separated parts of the world almost forgot each other. Europe, now well supplied with tin and copper, devoted itself to strenuous war and destruction. A thousand years or so later, when the Roman Empire had passed its prime, new silver mines were found in central Europe, and trade with the east began to revive once more. Venice was then the commercial center of the world, and it flourished as long as the Austrian and German silver mines were in bonanza, and when the cream of these was skimmed it began to decline. From that day till the years when Spanish galleons began to bring in silver from the new world, times in Europe were hard, civilization languished, and humanity suffered. Historians call the period the "Dark Ages." History also records the wonderful change that took place when the Mexican and Peruvian silver mines began to pour their flood of treasure into Europe. There was a marvelous revival of industry and of the arts and sciences, and the greater part of it was directly due to the enormous coinage of Mexican silver dollars, and their wide distribution in trade. This coin for three centuries has had a larger circulation, and has become more extensively known than any other tangible product of the hand of man.

From the date of the discovery of America up to about the beginning of the last century, the source of the world's supply of silver was almost entirely the mines of Mexico and of the west coast of South America. The production in this period is estimated by statisticians at nearly 200,000 tons, and its value (then about $30,000 per ton), at $6,000,000,000. The bulk of this vast total went first to Europe, and more than half of it in the shape of coins of American mintage. The remainder went into European coinage and plate. In those days it was not generally known that American silver always carried more or less gold, or else the methods of parting the two metals was very imperfect. Whichever was the case it is a fact that all the coins made in that period carried from two to five per cent of the yellow metal, and if any quantity of them could be now bought up at the commodity price of silver it would be a most profitable operation to separate the associated gold. This great store of what was, in those days, a money metal of unlimited legal tender value, enabled the new world to buy what it needed of Europe, and permitted the latter to resume its trade with the far east. Thus the old story was repeated. The pioneer, going westward, sends home the wealth he acquires through tremendous hardships, and upon this those who stay behind live luxuriously, or at least comfortably, as long as the good times last. And Spain, who was practically the parent and owner of those parts of the new world whence the metal came, prospered prodigiously, and became the wealthiest of the nations. But in 1810 its much-robbed and over-patient colonies began their struggle for independence. Spain resisted strenuously, and beggared herself in the effort to retain them. One by one, however, they tore themselves loose from her rule. The contest lasted through more than a decade, and during it the silver-mining industry suffered greatly. In South America it was almost suspended. The supply of the metal in Europe for coinage became scant, and trade with the orient again declined. In the middle of this period, when the destructive career of Napoleon was coming to an end, when all Europe was in financial distress, and vast amounts of plate had gone to the melting pot to be transformed into coin, with silver advancing in value (in terms of gold) until it commanded the equivalent of $1.40 to to $1.45 per fine ounce, with existing coinage of some of the nations in process of debasement by the addition of lead and tin to the alloy, England, in 1816, went on the mono-metallic gold basis, and started the train of conditions that later (in 1873) resulted in the complete demonitization of the white metal. And in this connection it is a most curious fact of history that while England in 1816 abandoned silver as a money metal because of its scarcity and high relative value in terms of gold, the rest of the great commercial nations followed her footsteps nearly fifty years later because of its abundance and falling value.

During the long struggle between Spain and her colonies the mining industry of Mexico was also greatly injured. When the country became independent in 1821 it passed into a condition of anarchy that lasted almost a half century. In this period its mines were operated under the greatest disadvantages, and the amounts of the metal exported was comparatively small. But as soon as political affairs in the republic became settled by the accession of President Diaz to power, the mining industry immediately began to revive, and to-day its output of the white metal exceeds that of any other nation.

Previous to 1859, when silver was first discovered in the United States (in Nevada), silver mining was not an organized industry in any sense of the word, but an occupation dependent largely for success upon the accidental discovery of bonanzas of very rich ore, and the ability to secure labor upon a basis of practical slavery. The Mexican and South American mines were worked by natives who were clothed, fed and sheltered merely to a sufficient extent to keep them alive during the prime of their physical powers. Only one step on the road of progress had been taken in the metallurgy of the metal, namely, the invention of what is known as the "patio process," which depended for its success largely on the element of unlimited time for its operation, coupled with nearly costless animal power. But when it became evident that the Comstock Lode in Nevada contained vast quantities of silver, the natural ingenuity and aptitude of the American transformed mining into a commercial industry, and the metal began to pour in such torrents into the money centers of the world that financiers became alarmed, and between 1870 and 1873 full coinage rights were finally denied by the principal nations. Meantime, a remarkable industry had come into existence in the mountain regions of our west. Thousands of silver mines had been discovered, scores of processes invented and put into practise for the treatment of their ores, and a vast number of metalliferous deposits developed that have since been yielding copper, lead, zinc, iron and manganese in addition to the white metal.

Silver occurs in veins or deposits in the rocky crust of the earth, and is never found in the gravel of stream beds as is gold. In a small number of cases the gangue, or material with which the metal is associated, is quartz alone, but generally one or more of the base metals is present, predominating vastly in quantity, and often in value. This is especially true after a little depth is gained on the veins, so that in due time mines that were opened as straight silver deposits became rather deposits of the other metals, the silver being practically a by-product. A good example of this change is to be found in the lodes of Butte, Montana. The veins at Parral, Pachuca and Guanajuato in Mexico are samples of straight silver mines, yet all of them are showing more or less associated iron or copper as depth is gained. On the other hand, wherever lead is found, silver is always present in some quantity, and, at the Comstock as well as at the Mexican districts just mentioned, there is invariably a proportion of gold. In the Comstock bullion it amounted to 40 per cent. of the total values. Thus the metallurgy of silver ores is not a simple matter, and in the days between 1860 and

1873, when the metal had a value of about $1.30 per ounce, a vast amount of study and experiment was devoted to the question of recovering it from its ores by milling processes, or methods not involving the fusion of the minerals. Preliminary roasting (sometimes in the presence of salt), followed by long-continued grinding with mercury, under water, was the system adopted in the majority of cases, the result being an amalgam of mercury and silver. This was then heated in retorts to volatilize the mercury, and the silver left behind was melted and cast into bars for shipment to market. Other processes involved the use of chemicals by the aid of which the metal was brought into a state of solution, and from which it was recovered by some method of precipitation. But as the west became opened by railroads so that ores could be cheaply transported to natural centers where coal or water power existed and labor was abundant and inexpensive, most of these processes were abandoned in favor of smelting, in which the ores, properly mixed to secure fusion, are melted in a blast furnace. The products are either copper or lead bars—according to the system used—and during the melt the precious metals unite with the baser ones, from which they are subsequently separated by electrolysis. In consequence of all this the production of silver may now be considered as a settled industry, and because the metal is now produced very largely as a by-product.

Since its discovery in the United States, and the application of business methods to the mining of its ores and their treatment, the world's output has amounted to nearly 170,000 tons. There has been nothing comparable to this enormous yield in any previous era of its history, and its fall in value may be considered as warranted, and perhaps permanent. The annual output of the world at the present time averages about 6,000 tons, and is not at all likely to seriously decline. The American and Mexican mines show no signs of exhaustion. On the contrary, new ones are continually being found. Asia and Europe are not likely to become large producers of the metal. The settled parts of the old world have been fairly well explored, and in the unsettled parts like Siberia, Turkey and Africa the mining laws are so burdensome that the prospector and individual miner (who are the advance guard in the exploration of the mineral resources of a land) will have nothing to do with those regions. In Australia somewhat similar conditions prevail. We may, however, confidently look to South America for many new and great silver mines, when the political situation becomes as stable as in Mexico, for Spanish mining law has always recognized the necessity of the prospector at the base of the industry. The extent to which the American crop of silver is a by-product is shown by the following table worked out by the author for the year 1899, when the product of our mines amounted to about 2,100 tons.

	Tons	Per Cent.
Produced in connection with lead ores	750.75	35.75
Produced in connection with copper ores	514.50	24.50
Produced in connection with gold	504.00	24.00
Produced in connection with iron and manganese	173.25	8.25
Produced from straight ores	157.50	7.50

In Mexico, on account of the activity in Parral, Pachuca and Guanajuato, the proportion of silver coming from straight ores is larger, and perhaps the same is true for South America. But in Europe, Asia and Africa practically the entire product of silver comes from the distinctively lead and copper mines, so that for the entire world the proportions quoted in the above table would be about correct.

The demand for the metal is growing and may be expected to increase markedly in the near future. The largest consumers now, as in the past, are the three great backward races of the far east, the Hindus the Malays and the Chinese. It takes from 2,500 to 3,000 tons every year at present to maintain trade with them, and but one, the people of Hindustan and Farther India, may be said to have been more than wakened from their sleep of centuries. These number about three hundred millions of frugal, industrious and acquisative people. When the four hundred million of Chinamen are thoroughly aroused, and the one hundred million of mixed races that include the Filipinos and the inhabitants of the East Indian Islands, there will come at least as large a call for the metal as that which now exists. For silver is the only money that the orient recognizes, or can use. The capacity of that part of the world for absorbing it has always been the wonder of economists, to whom Asia is known as "the sink of silver." Statistics show that an average of not less than 600 tons of the metal has been sent to the east by Europe annually during the last 300 years. Practically none of it has ever come back. Among the thousand million Asiatics it has disappeared as hoards of coin, or bars, or as ornaments, or is afloat as money. This curious process is in progress to-day with nearly fivefold the vigor of the past. Practically seventy per cent. of all the silver produced in Europe and America since the dawn of history is now in the possession of the Chinese, Japanese, Malays and Hindus. Yet we regard them as a poverty-stricken people, which in fact they are, for with all this immense hoard of what was once the paramount money metal of the world, famine or pestilence is abroad nearly every year in one or more parts of the orient. This vast metallic accumulation will not save them when crops fail and starvation is at hand, for the west, having demonetized silver will not accept it in exchange for food except on the basis of a pure commodity.

From 400 to 500 tons of the metal is at present being consumed by the world in manufactures and the arts. Such parts as are used in photography and by the chemist may be regarded as lost, and it amounts to as much as 50 tons per year. The balance becomes table ware, jewelry and ornaments. About 5,000 tons goes into coinage. Fifty per cent. of this is minted in Asia, approximately twenty-five per cent. in Europe, fifteen per cent. in Mexico and South America and the balance in the United States. All this, except the coinage of India, Mexico and Japan, is bought by the various governments at the commodity value of the metal, and after taking the stamp of the mint goes out to the public on the basis of the old ratio of 16 to 1 as compared with gold. The difference is absorbed as profit, under the name of seignorage. This profit to the treasuries of the civilized nations is now amounting to something more than $10,000,000 per annum, and is somewhat of the nature of a fraud on the people, though with the existing conventions in the matter of money and coinage it is not easy to say how the fraud can be avoided.

Considered wholly by itself, and from the standpoint of its purely physical properties, silver is yet a precious metal. Its pure white color and soft luster can not be approached in aluminum, tin, nickel or any other metal, and though it tarnishes quickly, and has not the resistant qualities of gold to the action of acids and of sulphur, yet no metal we at present know of can take its place for small coinage, or for ordinary table ware and decorative purposes. Aside from these uses it is the best conductor of electricity of all known substances, and there may be a special future for it in the wonderful development of that new servant of man. Perhaps as the science of wireless telegraphy and telephony advances silver may come to be employed in the reproduction of sound waves when great distances must be bridged, or extreme delicacy of enunciation is desired. Yet copper approaches it so closely in electric sensitiveness, and is so much more abundant, and consequently cheaper, that we are not likely to do much of our talking in the future over silver wires.

The world's crop of silver during the year 1907 amounted to about 6,400 tons, and came from the following parts of the globe in about the quantities given:

	Tons		Tons
Mexico	2,300	Europe	760
United States	1,900	Australasia	440
South America	420	Japan	120
Canada	400	China and Malaysia	15
Central America	35	Africa	10
			6,400

From these figures it appears that nearly 80 per cent. of the annual product is coming from the western hemisphere, and if we add to this the output of Australasia, the proportion coming from what may be regarded as the newer parts of the world, so far as the question of its civilization is concerned, rises to 85 per cent. Finally, by including the European product, it will appear that Asia, where the metal is most in demand, and where it still retains all of its old debt-paying quality, produces less than 3 per cent. of the total world's crop. Hence there is still a large field for silver in the orient, and its exploitation and development is undoubtedly the next great task of the Caucasian. And in this view the silver miner may take some comfort.

JAPANESE WRITING

BY E. W. SCRIPTURE, PH.D., M.D.
NEW YORK CITY

SOME time ago a Japanese student handed me the following statement:

> In Japan we aim at two distinct objects in giving instruction in writing. One is to teach the children the mode of writing ordinary characters, and to make them acquainted with the management of the brush. But we have another important object in teaching writing; in Japan it is regarded as one of the fine arts. Japan is a land of hero-worship. Nothing delights us more than the memory of great heroes and sages of the past. Every relic connected with them is cherished as a visible token of their great minds. We believe ourselves to be especially inspired and ennobled by their autographs. So the educated classes decorate what is set apart as the sacred part of the room—called "Tokonoma"—with such an autograph. We study the writings of eminent persons as a physiognomist would study the various expressions of human faces to know their inner characteristics. When we are trying to copy after an eminent writer we feel very much as we would when standing in front of a marble statue of a great man. Therefore we pay special attention to the posture of every limb of our body, and especially to the management of the brush, for we think we are in the presence of that hero himself. In that moment we concentrate our mind to direct all the energies of our body in a certain definite direction, in consequence of which our lower passions and appetites are extinguished as the dark clouds of night are dispersed by the radiance of the rising sun, and our spirits are freed from all the cares and anxieties of the present world and are wafted to the ideal region of highest felicity, where we commune with the holy spirits of the great heroes and sages. It was thought by the sages of old that by means of such a method of writing they could regulate the outward postures of their disciples and in consequence could discipline their inner spirits, So they counted the art of writing as one of the "Six Arts" by which they sought to edify man's character.

In Japan writing plays an important part in the social life of the people. On the second of January, on which day the work of the year begins, educated persons—especially the younger people—try their new brushes on specially prepared paper by writing sentiments in praise of nature and by expressing their wishes and hopes for the coming year. The Japanese give writing-parties just as we do lawn-parties and euchre-parties. At these gatherings the guests exhibit their best pieces of writing and receive prizes. Again, a piece of silk with an elegantly written sentiment serves as a highly acceptable wedding present. Even the walls of the rooms are decorated by writings in place of paintings.

FIG. 1. MANNER OF LARGE WRITING.

Writing is also a part of the divine service of Buddha. The empresses and emperors in the olden days made copies of the Sacred Books; the characters were golden on a white field, the style of the letters was dignified and beautiful. There is even a special god of writing, Ten Jin. He was a great statesman, poet and scholar of the olden time, and also a fine writer; he was afterwards deified. Now the children offer up to Ten Jin their early attempts at writing and pray to him for help in the difficult task which has been set before them. The sacredness of the art of writing attaches even to pieces of paper with written characters on them; the Japanese do not allow them to be trampled into oblivion, but carefully pick them up and religiously burn them.

What is our American view of writing? We consider illegible and careless writing a thing to boast of. You have all read Mark Twain's story of the letter from Horace Greeley, and I need not repeat it to

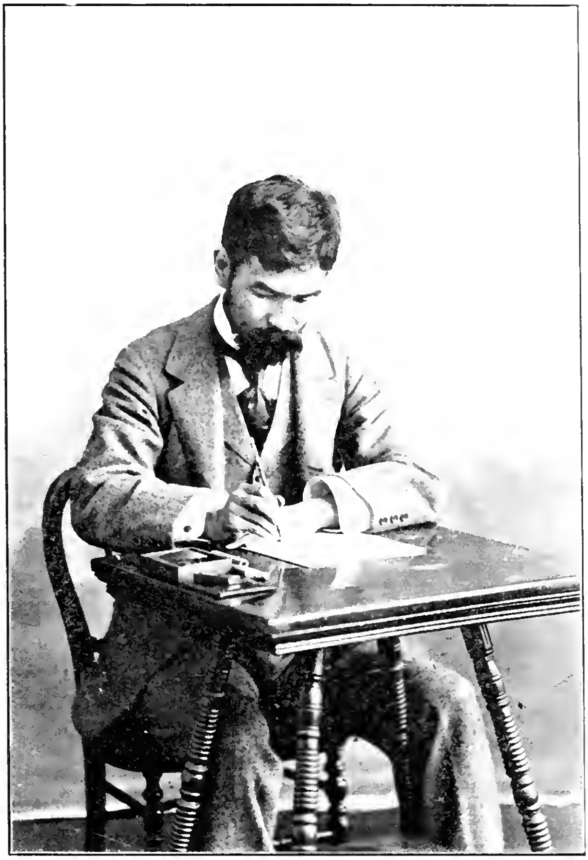


FIG. 2. MANNER OF FINE WRITING.

illustrate the point. The story is told of Rufus Choate that he wrote three hands: one which he could read and his clerk could not, one which his clerk could read and he could not, and one which nobody could read. Of a certain well-known Baltimore clergyman it is stated that he could not read his own manuscript twenty-four hours after he had written it. Similar anecdotes might be collected by the hundred. It does not matter whether they are literally true or not; the fact remains that the humorous way in which bad writing is treated shows that the general public sentiment regards poor writing as a thing to be proud of rather than otherwise.

Writing is to us a means of communication to be used as economically as possible—the biggest amount of communication with the least expenditure of pen-energy. Of course, from this point of view the best writer is the typewriter, and when typewriters are cheap enough we can expect the school-children to be taught typewriting instead of pen-writing.

This commercial view has brought it about that writing is no longer on a level with spelling; bad writing is excusable, but bad spelling never. This careless and frivolous treatment of the art of writing is, I maintain, an ill-bred trait of national character which we should endeavor to correct on the principles followed by the Japanese.

In Japan writing was regarded as one of the six arts of education. By the six arts were meant the postures, writing, riding, shooting, mathematics and music. The object of these arts was to teach the control of both the body and the mind. By writing, the control of the arm, hand and fingers was to be taught. The Japanese use the "Fude," a peculiar kind of brush made of the soft wool of the white rabbit. Fig. 1 shows the position for large writing. The long roll of paper is held in the left hand; the characters are written downward. The stone block on which the stick ink is rubbed in water is shown on the table. In the first stage of writing they have to learn to write large letters and characters. When they want to write large characters, it is forbidden to support the arm on the table or anything else. The movement of the arm must be entirely free in both the horizontal and the vertical direction. Not only are quickness and steadiness of movement required, but the arm is trained also to graceful movement and slow adjustments. Now a bold stroke is demanded and then a hesitating touch of the brush is required. It is said that "Sometimes the stroke of the brush must be as rapid and as dreadful as the lightning in the sky, but sometimes it must be as gentle and as graceful as the young virgin in her private apartment."

In the second stage of writing they have to learn to make smaller characters. Here again the arm must be free; but in this case one point of the wrist is supported on the table, or more properly on the row of fingers of the left hand laid on the table (Fig. 2). This point serves as a fulcrum for the movement of the hand and fingers. The object of finer writing is not only to train the fingers, but also to train the eye. So they are sometimes required to write characters not larger than a millimeter square. Even in writing such a small character, every jot and every tittle must be brushed according to a definite form of writing and by a single stroke.

We must change our American views of writing. In communicating by speech a well-bred person tries to avoid mutilations and transformations of language that might be offensive to cultured ears. The New Englander tries to save his g's, the Southerner to keep his r's, the Englishman not to drop his h's. In communication by writing, however, you may insult your correspondent by characters over which he has to puzzle long to derive any meaning; you may flaunt slovenly y's and g's and b's before his face; you may offend his nostrils with the garlic of reversible n's and u's, etc. This is quite wrong. Let your "Dear Sir" and your "Yours truly" speak their meanings in their forms as well as in their spelling; treat your friend with the politeness of legibility and feed your correspondence-guest with a meal of words more than half done.

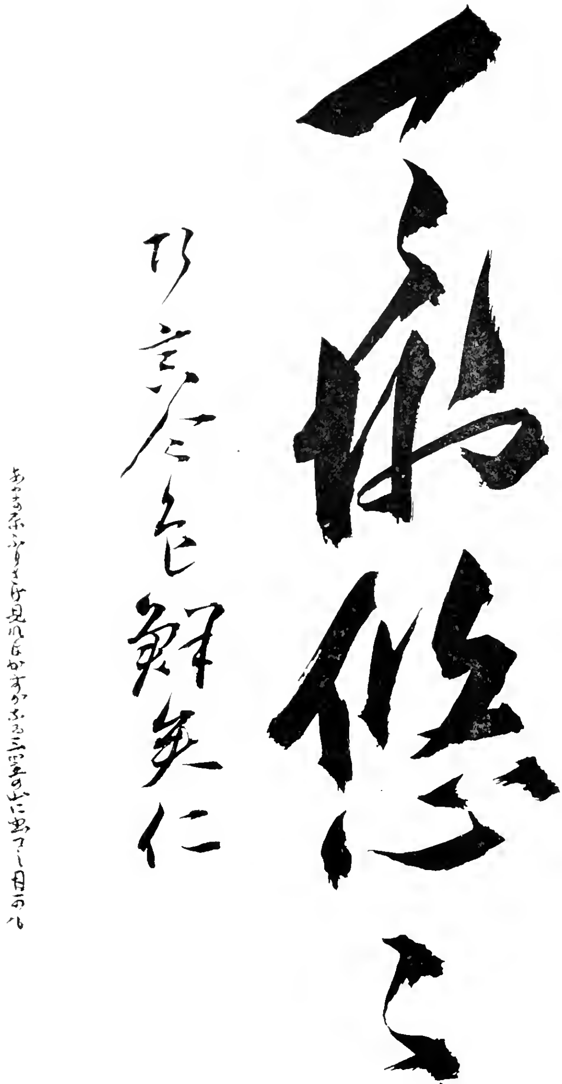


Fig. 3. Specimens of Writing.

It is especially when we consider writing as the expression of ourselves that we understand the Japanese feeling toward it. The voice and the hand are two great means of expressing what is in us. Our thoughts, our instincts, our very natures find expression in the tones of the voice; we are familiar with the effeminate voice, the manly voice, the sympathetic voice, the mean voice. Our hands also tell similar stories, but we have never learned to recognize them because we have not thought the matter worth considering. No facts whatever are yet settled concerning the relation between character and writing, yet that need not trouble us. It is a well-established law that our mind seeks expression by movements and that the practise of the movements tends to confirm the condition of mind that produces them. Certain attitudes are connected by repetition with devotional impulses; the mere assumption of such an attitude will arouse the same impulses. The careful putting of our best instincts into our writing on every occasion can not but have some of the moral effect attributed to such a practise by the Japanese, and the constant effort at clearness, correctness and gracefulness in expression must inevitably have some influence on our inner selves.

THE PROGRESS OF SCIENCE

THE LIFE AND LETTERS OF HERBERT SPENCER

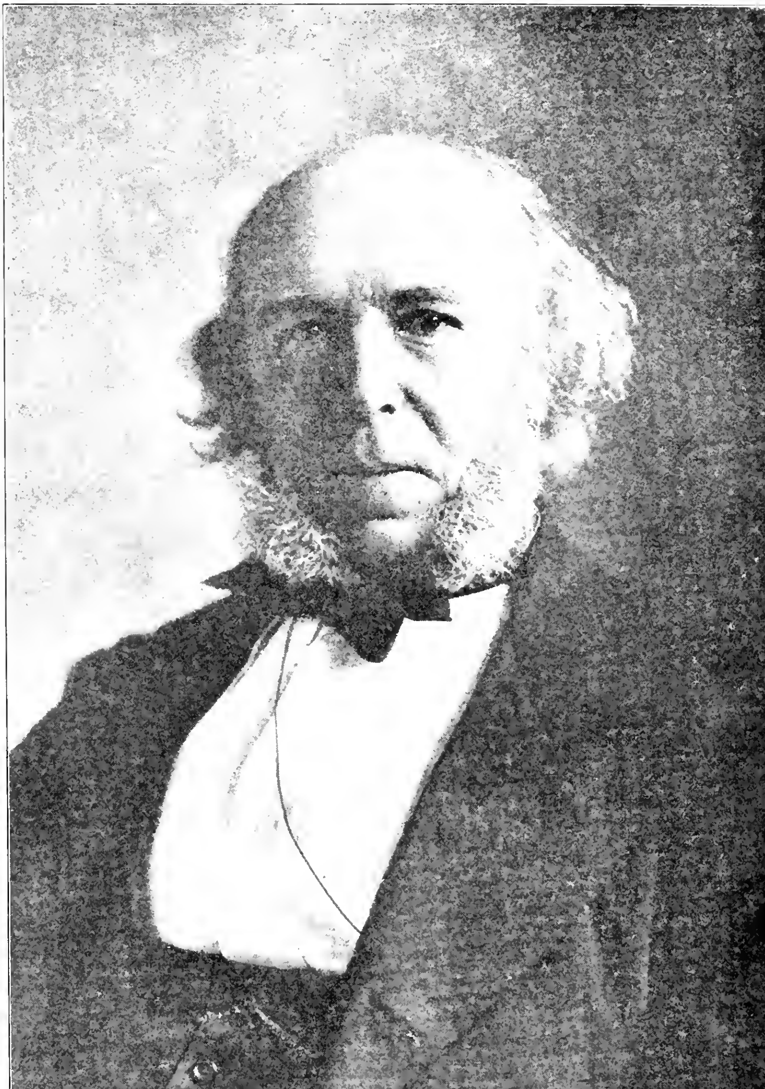
Spencer's "Autobiography," stereotyped during his lifetime and published in two large volumes shortly after his death in December, 1903, is now followed by two further volumes, a "Life and Letters," prepared by Dr. David Duncan in accordance with a clause in Spencer's will which read as follows: "I request that the said David Duncan will write a Biography in one volume of moderate size, in which shall be incorporated such biographical materials as I have thought it best not to use myself, together with such selected correspondence and such unpublished papers as may seem of value, and shall include the frontispiece portrait and the profile portraits, and shall add to it a brief account of the part of my life which has passed since the date at which the Autobiography concludes."

Dr. Duncan, who was Spencer's secretary and assistant for two years in the late sixties and was subsequently in India as professor of logic at Madras, had a task made extremely difficult by the preexisting autobiography. This, like all Spencer's works, makes a different appeal to different minds; some find it tedious, while to others it is of absorbing interest. In any case it is a work of genius written by a man of genius. It is so full and complete that most of the material of real interest had been used, except for the last years when Spencer was a confirmed invalid and found his own life wearisome.

Spencer says: "It is a provoking necessity that an autobiography should be egotistic." As a matter of fact the autobiography emphasizes the egotistic, the priggish and the petty sides of his character much less than does the biography, while the true largeness, sincerity and kindliness of the man emerge

Herbert Spencer when nineteen

Herbert Spencer when forty-six



Herbert Spencer
when 73

in the autobiography more clearly than in Dr. Duncan's pages. Indeed the lack of skill and tact in the biography gives the impression of a tinge of maliciousness. It is all very well to reproduce the accounts of Spencer's amiable foibles, given by Mr. Galton and Lady Courtney, but it is scarcely necessary to quote the letter according to which Carlyle called him "an immeasurable ass," and the amount of space given to his attitude towards the honors he declined, to his misunderstandings with Huxley and Harrison and to the difficulties about his portrait is out of proportion to their significance. It is proper to quote Spencer as writing: "Twice or thrice I have taken up Plato's *Dialogues* and have quickly put them down with more or less irritation," but then it seems scarcely desirable to close the biography with "What Professor Theodor Gomperz says of Plato may be said of Spencer," etc. The care that Spencer took about his autobiography and biography compared with Darwin's belief that his autobiographical sketch would be of interest only to his children places in sharp relief a real difference in character which is fully confirmed by all we know of the two men. Still, the inference may fairly be drawn that it is better for the reputation of a great man to have his biography written by his son than by his private secretary.

It would not be possible in a brief note to select material from the "Autobiography" and from the "Life and Letters" which would give any impression of Spencer's life and character, and it is of course out of the question to attempt to expound, appreciate or criticize the vast contributions to philosophy and science which have had such a large share in making the evolutionary standpoint dominant everywhere. Readers of this journal are familiar with Spencer's work, for he contributed to it nearly a hundred articles. It was indeed established by Dr. E. L. Youmans in 1872 largely with a view to provide a suitable medium for printing Spencer's "Study of Sociology," and the POPULAR SCIENCE MONTHLY may be regarded as one of the by-products of his genius.

The "Life and Letters" is published by Messrs. D. Appleton and Company, who for fifty years have been performing an important service by giving to American readers authorized editions of the works of Spencer, Darwin and Huxley. By their courtesy we reproduce the accompanying portraits.

THE FINANCIAL STATUS OF THE PROFESSOR IN AMERICA AND IN GERMANY

THE second bulletin of the Carnegie Foundation for the Advancement of Teaching, issued under the title given above, contains information that is of interest not only to those who receive salaries from American colleges and universities, but also to all those who realize that the future of our civilization depends largely on ideals of service and research for which the university is the natural home. There is no more important question than how the best men can be drawn to the universities and how they can be led to do their best work. The part played by salaries in accomplishing these objects is not obvious. It might be that large salaries would attract the wrong kind of men and lead them to spend their time in unwise ways. Ecclesiastical and military organizations, which in the past have developed the ideals of loyalty and service which should now be found at our universities, have not been dependent on salaries, though office and honors have played a considerable part. In an industrial democracy, however, it seems that men are likely to be esteemed in accordance with their incomes, and if the office of professor is to be made honorable it must be well paid, or at least certain positions must exist that are highly paid.

The statistics in regard to salaries

now published by the Carnegie Foundation give details for 103 institutions paying $45,000 a year or more in salaries to the instructing staff, and of 54 smaller institutions which were selected as showing that good results can be obtained with comparatively small resources. The average salary of the full professor in the hundred leading institutions is about $2,500, varying from about $4,800 to about $1,400. Higher salaries are paid in a few cases, but salaries of $5,500 at Harvard or $5,000 at Columbia are practically the maximum money prizes open to teachers. These prizes are not open to free competition; for in this country a professor can as a rule only reach the highest position in his own institution. In this regard, the German method of calling a man freely to what is regarded as a better position has certain advantages. A professor may be called to Berlin at the age of sixty, receiving a higher salary and a more honorable position than any that we have, and this possibility may be a stimulus to good work. Here a man who receives the average salary of $2,500, at the average age of appointment of 35 years, is not usually able to look forward to further promotion. His expenses increase, especially if he has a family, and he finds himself less well off than the successful physician and lawyer in the same town, who are continuously increasing their incomes and the material advantages they can give to their children.

The Harvard plan seems on the whole to be the best hitherto put in practise in this country. After a graded series of promotions and increments of salary, a full professorship is reached at the average age of forty with a salary of $4,000, and the salary is increased by $500, at intervals of five years, until it reaches $5,500. If a man shows unusual ability—ordinarily it must be acknowledged by being called elsewhere—he may be promoted more rapidly than in accordance with the usual routine; in general, however, the salaries are not in proportion to ability or to needs, but are equal with slowly increasing increment. This method and the system of pensions gives security and dignity to the office. It is an open question whether the lessening of competition and ambition which it favors is a good or an evil.

The comparison of the salaries given by different institutions should result in the improvement of conditions where these are unsatisfactory. Thus Syracuse University pays its assistant professors an average salary of $978 and its full professors an average salary of $1,808, and in its non-professorial departments has one instructor for twenty students. Haverford College pays its assistant professors $2,240 and its full professors $3,440 and has one instructor for six or seven students. These are extreme cases, but there are many anomalies in the tables. It is of course true that the effective salary is dependent on the cost and standard of living. A salary of $2,000 in a small town may have as much purchasing power as twice that amount in New York City.

SCIENTIFIC ITEMS

We record with regret the deaths of James Duncan Hague, the American geologist and engineer; of Anceto Garcio Menocal, an eminent Cuban engineer in the service of the United States government; of Mr. Arthur Lister, F.R.S., known for his work on the mycetozoa; of Mylius Erichson, the Danish explorer; of Dr. F. Noll, professor of botany at Halle, and of Dr. Oskar Liebreich, professor of pharmacology at Berlin.

Professor George E. Hale, director of the Solar Observatory of the Carnegie Institution, has been elected a foreign correspondent of the Paris Academy of Sciences in the place of the late Asaph Hall.—Count Zeppelin, on the occasion of his seventieth birthday, has been awarded an honorary doctor-

See the article by Dr. Philip B. Hadley in the June issue ate of science by the University of Tübingen. He has also been made an honorary citizen of the cities of Constance and Stuttgart, and has been given the gold medal for art and science by the King of Wittemberg.—M. Bouchard has been elected president of the Paris Academy of Sciences to fill the vacancy caused by the resignation of M. Becquerel to become permanent secretary. M. Picard succeeds M. Bouchard in the vice-presidency.

The monument in honor of Robert Bunsen, designed by Professor Volz, of Karlsruhe, was unveiled at Heidelberg on August 1.—The German emperor has supported the medical and scientific men in Berlin in objecting to the form of the monument designed in honor of Virchow. It is not a statue of Virchow, but introduces as the chief group a symbolic representation of his lifework, in the form of a struggle between a giant and a fabulous beast, while on a pedestal a medallion portrait of Virchow is placed.

The San Jacinto Valley in California will hereafter be known as the Cleveland National Forest. It has been so renamed by President Roosevelt in honor of the president under whose administration the first national forests were created. In 1897, in honor of Washington's one hundred and sixty-fifth birthday anniversary, and upon the recommendations of the National Academy of Sciences, President Cleveland created thirteen national forests, containing about 23,000,000 acres. The San Jacinto forest was one of the original thirteen so created.

In connection with an article by Dr. Philip B. Hadley on Johannes Müller, printed in the June issue of the Monthly, there was reproduced a portrait, which it appears was of Johannes von Müller, the Swiss historian. Our attention was called to this error by Professor George H. Parker, of Harvard University, by whose courtesy we are able to give a portrait of the great German physiologist.

THE POPULAR SCIENCE MONTHLY.

OCTOBER, 1908

SPOLIATION OF THE FALLS OF NIAGARA[1]

By Dr. J. W. SPENCER

WASHINGTON, D. C.

1. *First Reference to Niagara—Champlain.*—A few weeks hence there will be celebrated the three-hundredth anniversary of the foundation of the city of Quebec, by the Great Champlain. Out of this grew the Dominion of Canada. Although the establishment of the little settlement on the St. Lawrence River made Champlain most famous, it is not in this that his chief greatness lay, but rather in his wonderful explorations in the lake region of the interior of the continent, throughout a long life spent in the wilderness.

Jacques Cartier had ascended the St. Lawrence in 1535 and again a few years later. Champlain followed in his tracks as far up the river as Montreal (in 1603) five years before the settlement of Quebec. From the summit of the old volcanic mountain at Montreal he saw the first or Lachine rapids of the St. Lawrence, above which he could discern the smooth water of the expanded river, now known as Lake St. Louis. Here he received accounts from three different Indians as to the nature of the country beyond. Their communication must have been largely carried on by signs and diagrams, drawn on the sand. Although the first volume of Champlain's works is extremely rare, the accounts were transcribed by Lescarbot in his history of New France, published soon after, in 1609. The description of the rapids and various lake-like expansions of the St. Lawrence, the Thousand Islands, Lake Ontario, the occurrence of Niagara with its rapids, and Lake Erie reaching to Lake Huron "beyond which no man had been," were all so complete that a navigator unimpeded by hostile Indians could easily have found his way. But the natives were hostile, so that Lake Huron came to be known long before Lake Erie and the Niagara River.

2. *First Account of Niagara River.*—Champlain never saw Niagara,

[1] Address before the American Association for the Advancement of Science, June 30, 1908.

Fig. 1. Falls of Niagara, Canadian Branch, 1899. (By permission of Baker Art Gallery, Columbus, Ohio.) Sheet of water to the right of line *bb* (west side) has since been curtailed 415 feet, on account of power diversion. The falls to the left of line *aa* are being drained by the diversion, which, when it reaches the franchise amount, will leave 800 feet of bare rock on the Goat Island or eastern side, thus throwing the remaining falls entirely into Canadian territory.

but on his map of 1632 he represents a long series of rapids, located at the end of Lake Ontario, and says concerning them, "A very high fall of water at the end of the rapids of St. Louis (a name given to Lake Ontario) where many kinds of fish in descending are stunned." That the river was famous among the Indians, on account of the falls, and possibly among a few "*Courreurs de bois*" and missionary priests, is certain, as Father Lalement, who first mentions its name (Onguaahra), speaks of it as "so celebrated." This was in 1641, yet he does not mention the falls. In 1645, Dr. Gendron wrote a letter about the falls, but this was not published until 1660; in the meanwhile (1648) Father Ragueneau mentions them as occurring on Niagara River. This was the beginning of the historic period.

3. *Approaching Peril to Niagara Falls.*—The Falls of Niagara are now entering another and much more critical epoch in their history. The time has not arrived when their use has become a necessity, and even in their spoliation, other and larger interests are at stake. Niagara is a world possession, yet its very existence is imperilled by the greed of a few persons, or for the exigencies of politicians.

4. *Commission for Investigation.*—Extended operations were already at work upon the falls, when Dr. Robert Bell, Canada's most distinguished geologist, at the head of the Geological Survey, commissioned me, three years ago, to make a complete investigation upon the recession of Niagara Falls, so as to record the undisturbed work of nature, and also to determine how far the falls could be diverted without bringing about unforeseen disasters.

5. *Opinions of Power Diversion.*—At that time, in the opinion of some serious observers, the falls were imperilled, and Dr. John Clarke, state geologist of New York, pointed out the impending destruction of the American Falls. There were also many sensational magazine articles, bearing on the same subject, but in these no data were given by which to form judicious opinions. On the other hand, those interested in the diversion of the water insisted that no serious damage would be done. Personally I had no opinion whatever, though I regretted the disfigurement of the falls, through the structures erected by the power companies, one such being placed even beneath the cataract itself, inside the Park Reservation on the Canadian side, especially offensive as seen from the American side (shown in a succeeding plate, figure 8).

6. *International Waterway Commission established for saving the Falls.*—Before this time, the late Honorable Andrew H. Green had secured the passage through Congress of a bill, authorizing the establishment of an International Waterway Commission, his specific object being the preservation of Niagara Falls. Indeed it was for this same object that the International Park at Niagara had been established at an earlier date, largely through the efforts of the Earl of Dufferin,

Governor General of Canada, and Mr. A. H. Green, of New York, who subsequently prevented the intrusion of all power structures in the state reservation on the New York side, a policy unfortunately not followed by the government on the Canadian side. Here even the park was widened, at the cost of the falls, in curtailing their crest-line by several hundred feet. Yet among those interested in the power companies it was commonly said that they were improving the park; a few, who were powerless, seeing through this sophistry. That public opinion was swayed by such representations is not to be wondered at, for at a later date, April 26, 1906, the Canadian section of the commission states that, "It would be a sacrilege to destroy the scenic effect of Niagara Falls, unless and until the public needs are so imperative as to compel and justify the sacrifice" (p. 102), and yet they suggest no curtailment on the Canadian side. The report further says that, "It is possible to preserve the beauty, and yet permit the development on the Canadian side of the Niagara River"—of a certain amount of power on which I shall comment later, but no data are given on which the above statement is based. Indeed, I was unable to form any opinion whatsoever until my own investigations were made, which were begun before the proceedings of the International Commission, and not completed until some time after the premature report, cited above, appeared in print.

7. *Results, the Outcome of Purely Scientific Investigations.*—The conclusions reached concerning the spoliation of the Falls of Niagara are the outcome of investigations into purely scientific problems, and a brief account of them may show more convincingly how these results have been obtained. Just twenty years ago, I had the honor of announcing to this association the discovery that Lake Huron, with Michigan and Superior as tributaries, formerly emptied to the northeast, and did not discharge into a shrunken Lake Erie; and, consequently, Niagara was then a very small river. Six years later, I again laid before this association additional observations indicating that the falls had receded nearly three miles, when the Huron drainage was turned into Lake Erie; and with the fragmentary data bearing on the discharges of the rivers, an attempt was made, with only partial success, to determine the size of the original Niagara River.

One of the chief problems of my latest investigations was to determine the volume of the Niagara River in its early stages. It was not a simple matter, for contradictions appeared in the data obtained, which had to be eliminated. This involved the whole question of the physics of the rivers, requiring months of labor to collect the data and analyze them. In this connection, I found that the outlets of both Lake Erie and Lake Ontario had been recently lowered, while Mr. Thomas Russel, of the U. S. Lake Survey, had previously made the great discovery that the outlet of Lake Huron had also been lowered. This was the starting-point of the investigation into the spoliation of Niagara. The channel of the river had been deepened just after 1890, owing to natural scour by the currents, the effectiveness of which was increased by the powerful jamming of vast quantities of ice against the barriers at the Upper Rapids, immediately above the falls, and to a small extent by the shifting of the boulders on the river bed just below the outlet of Lake Erie.

8. *Corrections of Discharge Measurements.*—The discharge measurements had been made by the U. S. Lake Survey after the lowering of the lake outlets had occurred, that of the Erie outlet causing the subsidence of the lake level to nearly one foot. As the daily records of the lake fluctuations have been kept for fifty years or more, it was possible to determine the discharges of the rivers throughout that time. Failing to take into consideration this lowering of the lake outlets, the calculations of the river discharges prior to 1891 were excessive, and those of Lakes Huron and Erie showed inadmissible differences; as also found by Mr. Russel. These discoveries reduce the calculated discharge of Niagara River, prior to 1891, by 22,000 cubic feet per second, which would bring its volume from 1860 to 1890 into agreement with the mean measured discharge for the fifteen years from 1891 to 1905, inclusive, or 204,000 cubic feet per second; and the low water discharge has fallen to 160,000 cubic feet. There have been years of high water and others of low, yet by taking groups of years, the mean values are remarkably uniform, but the latter period must not be regarded as one of low water, a fact which I can not too strongly emphasize, although the lake levels have actually been much lower than during the preceding period, due, as just stated, to the lowering of the outlets. Such years, however, as 1901, showed very low water in Lake Erie, and reduced discharge of Niagara River.

9. *Present very High Water.*—In contrast with this, the lake-levels during 1907 were extraordinarily high, increasing even till the present month (June, 1908). Fragmentary information, preserved, indicates that Lakes Erie and Ontario were unusually low in 1819. The fuller record of subsequent years shows that the highest water occurred in 1838, and nothing has been comparable to it until the present high stages. Although these do not make the lakes appear to be now so high as seventy years ago, this is because of the lowering of their outlets and the further diversion of water for power purposes, both of which, if allowed for, would bring the lakes to higher levels than at any time since records have been kept. The 1838 period of high water began in that year and continued until 1840, after which the lake levels subsided to normal conditions. There is no reason to suppose that the present extreme high-water conditions will continue longer than

FIG. 2. VIEW OF UPPER RAPIDS, at the head of which is the rock-rim determining the distribution of water, as it leaves the basin above (descent 55 feet). This rock-rim also determines the level of the Upper Lakes.

on previous occasions, although I am aware of a statement by an engineer holding a distinguished position, to the effect that we do not know that the levels are going to recede. This appears to have been said for politic reasons, as the pressure to further divert the water is very strong.

There is much popular curiosity as to the cause of the high water, which is not wholly explained by the rainfall. Mr. E. S. Wheeler, of the U. S. Lake Survey, found in his elaborate study of the physics of the rivers that changes could be produced by ice jams holding back the discharge and raising the lake so high that upon the melting of the snows together with spring rains, the waters could not run out sufficiently fast during the ensuing season, so as to bring the levels of the lakes to their normal condition. These effects could accumulate during succeeding seasons so that the extraordinary stages might last not merely one year, but for several years.

From the foregoing, it must be apparent to any one that no opinions can be formed on power diversion which ignore the fluctuations of lake levels, for as these vary, so do the discharges of the rivers. The mean discharge of the Niagara River for 1901, a year of very low water, was 14,000 cubic feet per second below that of the mean level from 1891 to 1905. This was after the abstraction of a certain quantity of water, the exact amount of which is unknown to me, but probably not reaching 10,000 cubic feet per second. The mean discharge during 1907 reached 15,000 cubic feet per second above the average of the fifteen years mentioned; this being after the artificial abstraction of nearly 18,000 cubic feet per second. Thus the entire diversion of the Niagara waters has been not only concealed by the extraordinary stages of the river, but a further quantity could be withdrawn without any apparent effect upon the falls. The increasing discharge of Lake Erie, during this year, reached the maximum on April 27, when it rose to 60,000 cubic feet per second above the average of the fifteen years mentioned, besides which the diversion was probably nearly 18,000 cubic feet; so that the full use of the franchises of the present power companies would not impair Niagara Falls to-day, but this condition can not last, and it is unfortunate that it should occur at this time, for the sake of those who are interested in the preservation of the falls, as well as in the navigation of the lakes.

In studying the physics of Niagara River, individual months or single years can not be adopted as standards, but I have found that satisfactory results can be obtained by taking groups of five-year periods. Perhaps some other arrangement might prove better. This has resulted in my adopting as standards of lake levels and river discharges, the means of the fifteen years succeeding the lowering of the lake outlets, and the present temporary high water will doubtless adjust itself in the general averages, as on previous occasions, so that we must consider the effects of power diversion under normal conditions. As stated before, when the corrections are made in the discharge calculations prior to 1891, they fall into harmony with those of more recent date. These corrections do not appear in the work of any other writer, but I find them necessary, in order to explain incongruities, and to arrive at a satisfactory understanding of the effects of power diversion on Niagara Falls and the Great Lakes. Under these conditions, let us examine the physics of Niagara River.

10. *Basin above the Rapids.*—Above Niagara Falls are the Upper Rapids, descending fifty-five feet to the brink of the cataract. These begin as the water passes over a rim of rock (see figures 2, 3, 5) which crosses the river at the head of Goat Island. This is the "critical point," not merely in the distribution of water over the falls, but also in the level of Lake Erie, and indirectly of Lakes Huron and Michigan. Except at one small part near the Canadian side, the rock rim is from two to five feet higher than the rock-floor of the shallowest part of the river, about seventeen miles above the head of the Upper Rapids, and two miles below the outlet of Lake Erie. Throughout this distance the river crosses a depression, refilled with drift, so that here the channel itself was easily excavated to a much greater depth than across the two rock barriers mentioned, thus forming, *de facto,* a basin beginning with the narrows at the Buffalo Water Works, which are only 1,850 feet across, soon widening out into the broad stretches of the river on either side of Grand Island, below which they unite into another basin, over a mile wide, above Goat Island and its associated rock rim. This from its greater height than at the Water Works, constitutes the true rim of the Erie basin. The slope of the river between these points is due to the narrowness of the outlet of the lake, where the waters are so piled up that they have a velocity reaching to eight miles an hour, while in the basin above Goat Island the current is reduced, and is there from two to four miles an hour. The descent of the river from the lake to the rock rim at the Upper Rapids is about twelve feet.

11. *Depth of Water on the Rim of Upper Rapids.*—At mean stages, the average depth of the water in the American channel, as it begins to flow past Goat Island, is less than three feet, with a maximum of 4.5 feet. In the Canadian channel, for some 400 or 500 feet from Goat Island, under present ordinary conditions, the water is only from half a foot to one foot in depth, then for another stretch it increases to between two and three feet, beyond which the river shoals, so that in ordinary stages the water is seen to descend, not only in almost broken streams, but it is so shallow that the floats which have been sent down the river do not pass over the rock ledges, but are carried by the

dividing currents on either side. Thus for perhaps half of the river from the Goat Island side, I have estimated the mean depth of the water over the rock rim as not exceeding two feet. Indeed, much of it is not over a foot in depth. Nearer the Canadian side it increases to nine feet (see figures 3 and 5).

FIG. 3. PROFILE OF RIM OF FIRST CASCADE, with forebay of Ontario Power Company in foreground.

12. *Portion of Falls in Immediate Peril.*—As the river is so shallow over the rock rim on the Goat Island side of the main channel, it forms only a thin sheet of water on the eastern side of the Canadian or Horseshoe Falls, for a distance of 800 feet from the Goat Island end. Indeed, from the changes already effected, this sheet of water has been reduced in depth by sixteen inches, thus in many places exposing the shelf of rock over which the rapids are passing (figure 4). This portion of the falls I had considered as being in most immediate peril, even more so than the American Falls, but recent soundings, about the head of Goat Island, show that a rocky floor extends almost across to the main shore of New York, which in the future must divert to a large degree the supply of water from the American channel between the island and the shore. Accordingly, the American Falls are in equal danger with the eastern side of the Canadian cataract.

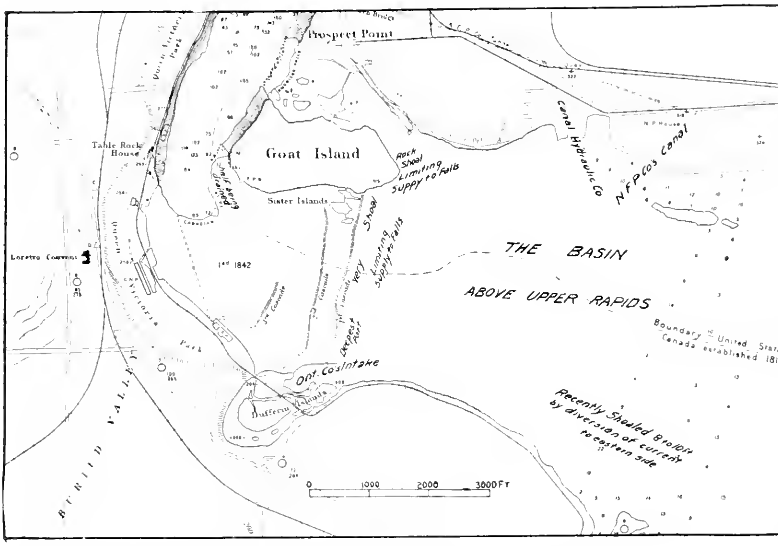
I hope that in this study of the physics of the river, the importance of this rim has been sufficiently emphasized; for any lowering of the water in the basin, will cause the draining of the higher parts of this rocky barrier, which extends nearly two thirds of the breadth of the

Fig. 4. Eastern Side of Falls being drained. Power House in the background is situated in the park on the Canadian side.

channel from Goat Island—thus affecting most the eastern side of the falls. If it were broken through, as it will be in the distant future by the recession of the falls, the water in the basin would be immediately lowered, and the Upper Rapids would reappear as a cataract just below the Buffalo Water Works, where the rock-floor is now seventeen feet below the surface of the river, while at a mile and a quarter farther down the drift has already been excavated to a depth of fifty-three feet.

13. *Artifical Openings now made in the Basin.*—It is immaterial whether the artificial enlargement of the orifice to the basin be made across the rim, or from its sides, or from the bottom. One lateral channel has been made for a breadth of 100 feet, and a depth of fourteen feet below the surface of the basin. There is also a neighboring one of about equal proportions. These made channels consequently reach depths much below the general level of the rock rim. They constitute the intakes of the two power companies on the New York side, and were calculated to carry 14,500 cubic feet per second at low stages (see map, figure 5).

On the Canadian side, the Ontario Power Company has installed a peculiar structure at the end of the rock rim, above which the river has a depth of five or six feet. Just below, at the natural edge of the basin, they threw out a wall, forming a wing-dam of some eight acres. This wall was brought to about the height of the river floor above.



- Fig. 5. Map showing the Position of the first Cascade and the Basin whose Level is now being lowered by the Power Companies.

The effect of this is to extend forward the rock rim of the basin. Behind this wall, they removed the rock floor, in some places to a depth of seven feet, so that there is now a general depth in their dam of some six feet below the surface of the barrier, over which the water flows as if naturally. By taking the water from the bottom of the dam, while the river is still flowing over the top, the same effect is produced as if it were taken by a tunnel from any part of the floor of the basin of the Upper Rapids, and so increases the discharge from the basin.

The franchise of the Ontario Power Company is about 12,000 cubic feet per second, but works for only 4,000 cubic feet are completed. Their franchise has not been restricted as have been those of the New York Companies. The present amount of water due the New York Companies, as restricted under the Burton Act, is 14,500 cubic feet per second, although their franchises gave them 27,200 cubic feet per second.

These detailed accounts are given to show unequivocally, despite assertions to the contrary made to me by Mr. George C. Gibbons, chairman and legal representative of the Canadian section of the commission, that not only the older New York Companies, but also the Ontario Power Company (the other Canadian companies' works being below the rapids) must lower the water in the basin above the Upper Rapids. Indeed, Mr. Gibbons signs the report stating that if the water-supply were taken from Chippawa Creek, Lake Erie would be lowered, as the supply would come from back-water derived from Niagara River. This back-water would be flowing from the same basin which has been described, consequently there can be no difference whatsoever from what point of the basin the water is diverted.

14. *Water taken from One Side of Basin affects the Other Side.*—That water can not be taken from one side of the basin without affecting the level on the other side is shown by the fact that, since the two New York companies began operations, the depth of the river, which is a mile across, near the mouth of Chippawa Creek, has been shoaled to the extent of eight or ten feet by the deposit of mud, owing to the slackened current in this part of the basin. So, also, when the power of the Ontario Company comes to be fully used, they will lower the water on the American Falls. Another proof of the diversion of water from the Canadian shore by the New York companies is the shoaling of the river just above the falls, where it was found necessary to throw a barrier to catch the water for the small local power plant, as the level of the river had sunk below the normal stage by the time one of the larger Canadian power plants was ready to begin operations.

15. *Power Diversion below the Upper Rapids.*—There are two other power plants situated in the Canadian Park, but below the Upper Rapids. Consequently, they lose much by their inferior head of water. This is a great gain, in that, taking the water some fifty feet below the basin, the overflow of the rim is not increased, so that this diversion produces no effect whatever on the lowering of the lake levels, or on the American Falls, or eastern side of the Canadian. These companies take the water from the deepest part of the channel, and consequently their effect is least apparent. Their aggregate allowance is about 20,000 cubic feet per second, or a net of 235,000 electric horse-power. However, much damage has been done to the western side of the falls, largely owing to the Canadian Niagara Power Company, on account of which the widening of the park has shortened the crest of the Horseshoe Falls by 415 feet, leaving in place of the sheet of water, a dark wall of rock stretching out into the gorge. It is strange that this impairment seems already to be almost forgotten except by a few lovers of the great cataract, but on looking at the Canadian Falls from the upper bridge the effect is to reduce the diameter apparently by one fourth (see figure 1).

16. *Water taken by Canals.*—The Welland and Erie canals divert less than 2,000 cubic feet per second, and, while the Chicago drainage canal takes at present scarcely more than 4,000, its rights extend to 10,000 and they want 14,000. The diversion by the Chicago canal of 10,000 cubic feet produces varying effects in the different basins, but it may be given at a lowering of the lakes by six inches, or some three inches for the basin at the Upper Rapids.

17. *Effect of Power Diversion on the Falls.*—We are now in a position to determine the effect of power diversion upon Niagara Falls and upon the navigation of the lakes. The water taken from below the

rim on the Canadian side may be omitted from the present discussion. This leaves a volume of 51,200 cubic feet per second, including that of the Chicago canal, conceded under the franchises, though temporarily limited to 44,500 cubic feet. At the beginning of 1908 there were approximately only 18,000 cubic feet per second in continuous use out of the amount affecting the basin (and this quantity may have been considerably reduced from the shutting down of some works), yet this diversion, together with the scour on the river, has lowered the water in the basin, immediately above, so that its level is sixteen inches lower than what it would have been, if no such changes had been effected. Half of the amount is due to the diversion of the water. It is this lowering of the water, just before passing the rim of the basin, at the head of the Upper Rapids, which is causing the lowering of the water on the falls, as shown in figure 4.

In confirmation of the above results, let it be stated that on June 14 a power company stopped its use of 8,000 cubic feet per second, and this caused the water in the basin to rise six inches (the diversion by the other companies and that of the Chicago canal was not arrested at the time). At the edge of the American Falls the water rose 1.2 inches.[2] At mean water much of the American Falls is scarcely more than six inches deep. With the lowering from extraordinarily high water to normal conditions, and the diversion increased in the future to 44,500 or 51,200 cubic feet per second, taken from above the Upper Rapids, the basin will be further lowered from twelve to sixteen inches or more, so that much of the rim of the basin will be exposed, and thus the flow of water will be largely cut off, not merely from the 800 feet on the eastern side of the Canadian Falls, thereby destroying that part, but also curtailing the water on the American Falls to half its present normal amount, which is only 5 per cent. of the total flow of both cataracts. This will be still further aggravated during years of low water, such as was 1901.

The preservation of the falls is now a question of inches. Under the conditions as set forth, the whole of the Horseshoe Falls will have shrunken from a crest line of 2,950 feet to 1,600 feet (including the curtailment on the Canadian side), and their diameter will have been reduced from 1,200 to 800 feet (see figure 6). They will then be

[2] It was telegraphed all over the United States that the rise was only a tenth of an inch, with congratulations of proof that no harm was being done to the falls. The term tenth-of-a-foot is one which would be used by engineers, but never in popular language, which depends upon inches. Hence the conclusion, jumped at, is partly explicable, especially by the promotion of power diversion at Niagara. But the change of depth above the Upper Rapids is that which determines the distribution and destruction of the falls. Besides, on the day of test, the discharge was 25,000 cubic feet and also nearly 18,000 more for power diversion above the normal discharge of Niagara River.

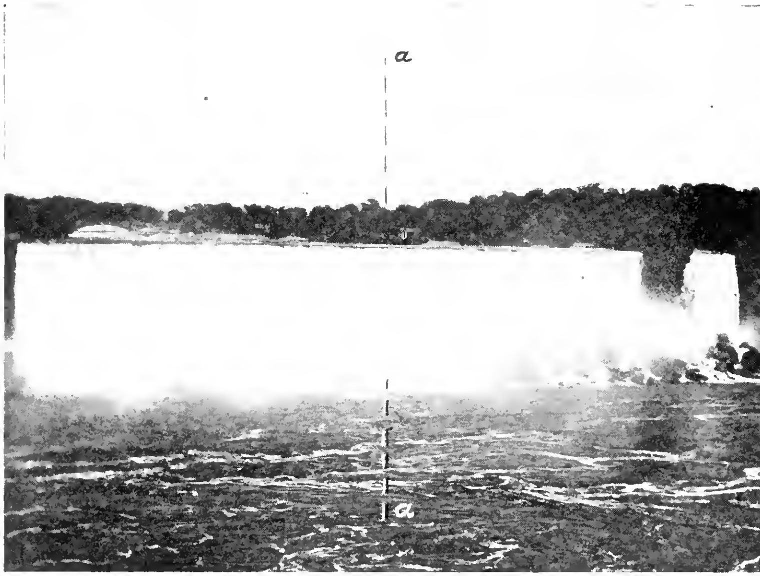


FIG. 6. NIAGARA FALLS, AMERICAN BRANCH. The half of falls on the right side of *aa* will be destroyed and that to the left damaged by full use of franchise amount.

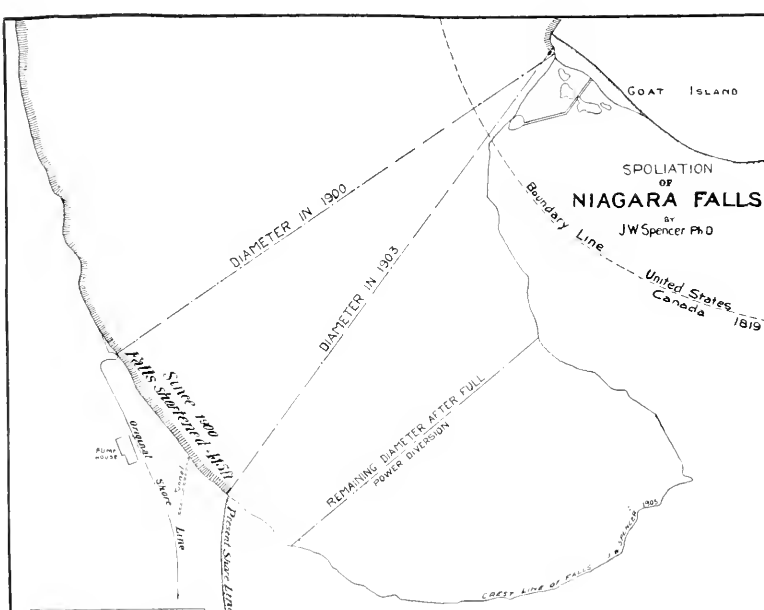


FIG. 7. MAP OF CREST LINE OF FALLS BEING SHORTENED FROM 2,950 FEET (IN 1900) TO 1,600 FEET UNDER FULL FRANCHISE DIVERSION; AND DIAMETER CURTAILED FROM 1,200 TO 800 FEET. The remaining falls will be entirely in Canadian territory.

entirely within Canadian territory, as the boundary line will become uncovered, leaving a narrow strip of rock between Goat Island and the great cataract. If the full franchise be used, the American Falls, which are 1,000 feet across, will have their southern half drained, as in figure 7, and will be further broken up into narrow sheets or strings of water.

Any attempt at restoring either the American or the eastern side of the Canadian Falls, by deepening the channels on that side of the river, would increase the velocity of the currents above and cause an extraordinary demand on Lake Erie, the result of which would be the lowering of its level at an enormous cost. The same physical changes would subsequently take place in the Huron outlet as a consequence of the lowering of the Erie level. The artificial deepening of the channel would also increase the scour, not merely of the Niagara River, but also the St. Clair channel, which lies in deposits of sand and clay.

Until such time as the use of the water shall become imperative, the preservation of the International Park and the falls is a very small bit of luxury or extravagance compared with the value and cost of great city parks, or even one of them, such as the Central Park of New York. But there is also a commercial side to this question. The yearly number of visitors to Niagara varies from 600,000 to 1,200,000 and the expenditure in transportation and at the falls is estimated as reaching sometimes $25,000,000 in a single year, giving pleasure and recreation to many people over the whole country. Are these considerations to be set aside for the gain of a few companies, or for political purposes?

A limited amount of power can be used without detriment to the scenic effects. Under the Burton act, the two New York companies are at present restricted to a developed capacity which is about half their franchises. The Ontario Company's franchise has not been restricted, although their present plant is developed to only one third its prospective size (figure 8). The full use of their allowance will affect the falls to an even greater extent than the Chicago canal, and bring into prominence the impending disasters, after the full use of the water at Chicago. The most strenuous endeavors are being made to extend the spoliation of the falls to its utmost limit, and recently the Ontario Company has sought permission to harness even the Whirlpool Rapids, which are fifty-one feet in height and only a little less imposing than the falls themselves. This company desires to obtain from twenty to twenty-five per cent. of the flow of the river, or nearly 400,000 gross horse-power, besides the privilege of disfiguring the gorge by their structures, such as the one already placed below the falls, though this at present is only one third of its prospective size, as shown in figure 8. There are two other great power houses in the Canadian Park. Those

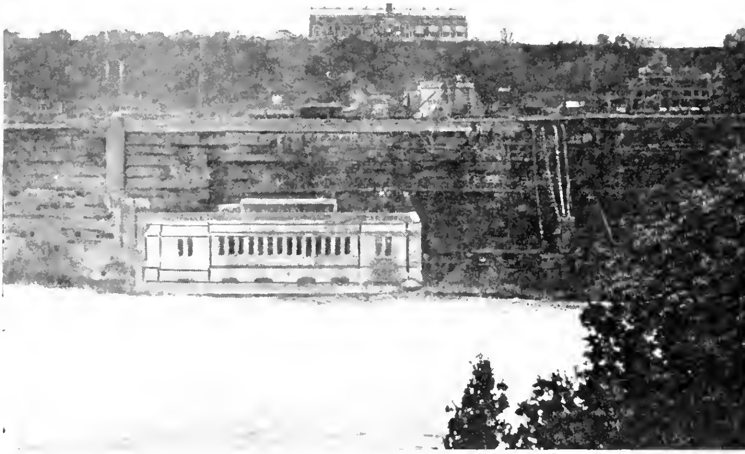


FIG. 8. ONTARIO COMPANY'S POWER HOUSE (270 FEET LONG) IMMEDIATELY BELOW THE FALLS IN THE CANADIAN PARK. This is only a third of the proposed length; even at present it is a most striking obstruction of the gorge, as seen from the New York side.

on the New York side are not in the park and can not be seen from the falls, but the eastern banks of the river below the park are crowded with works.

18. *Effects on Navigation.*—The canals and harbors are much shallower than they used to be. Several inches of this are due to the power diversion, which, however, is not at present seen, owing to very high water. The lowering of the level of the basin above the Upper Rapids, increasing the slope of the river, and consequently the velocity of the current, also lowers the level of the lake above. An increased discharge of 22,000 cubic feet per second lowers Lake Erie by one foot. On the large steamers in the carrying trade, each inch of draft represents a return of $100 in extra freight receipts. The canals and harbors should not be reduced in depth by power diversions at a time when there is a clamor for deeper channels. The impairing of navigation, under conditions as shown above, threatens to reach two, or even two and a half feet. Under the estimate made for the American Section of the International Commission, the cost of repairing the damage caused by the Chicago drainage canal was found to exceed $12,000,000, so that the total costs to both countries on account of power diversion promises to reach twenty-five millions of dollars or more. Are the power companies willing to pay for their share of this costly franchise, and for the loss owing to the diminished business going to and at the falls, which may reach $25,000,000 a year?

Unfortunately in the Province of Ontario it has become a political question, and there the government has adopted the Power Company which is causing the greatest amount of damage, although they could have obtained their supply from two other companies which are doing relatively little harm.

A prominent man at Niagara Falls, N. Y., has expressed himself as follows: "The subject of the diversion for power purposes is a burning question here, and a great number of unreliable and misleading statements have been made by interested parties to justify the diversion, stating that no damage will be done, and the work of Spencer" (referring to my recent book on the Falls of Niagara[3]) "is most timely in giving the results of a scientific examination of the whole problem, with the data on which the conclusions are based." In that work, the data are brought down only to January, 1906, but this contribution is based upon additional information extended to the present day, enabling me to give fuller and more precise results than in the original work.

The preservation of the falls now depends upon the governments at Washington and Ottawa. In the United States, apart from those interested in the diversion of the water, there is a wide-spread sentiment in favor of saving the scenic wonders of Niagara. But now another interest joins hands with this, which is economic and of great magnitude, namely, the protection of navigation. It is to be hoped that the national governments will so control the matter that this unique world-treasure will be preserved for all time.

At the present time the commission recommends the use of 28,500 cubic feet per second for the two restricted American power companies and for the Chicago drainage canal, while 36,000 cubic feet per second are conceded to Canada.

[3] "The Falls of Niagara," by J. W. Spencer, Geological Survey of Canada, 1907.

THE INDUSTRIES OF NIAGARA FALLS

By RAYMOND H. ARNOT

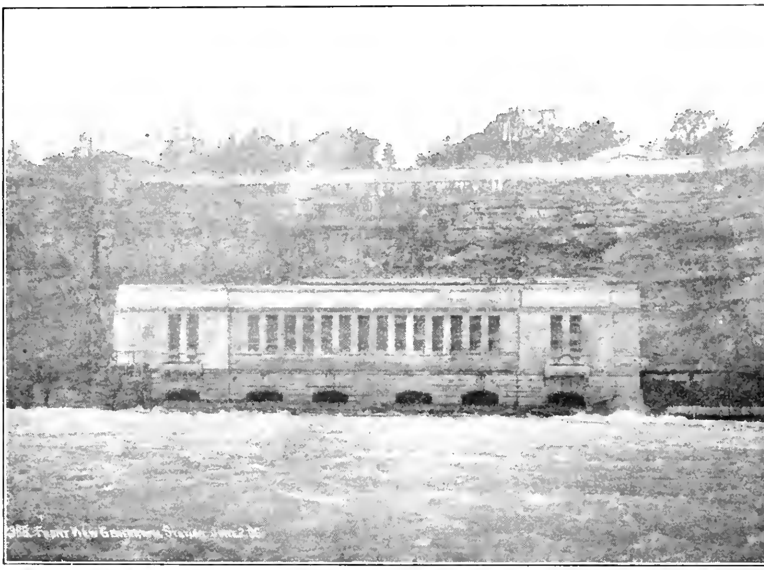
ROCHESTER, N. Y.

NOTWITHSTANDING the fact that the Niagara Falls region is chiefly celebrated by reason of its natural wonders, intelligent people are gradually coming to understand that here are to be found engineering works in the form of electrical-power development plants which are unrivaled anywhere in the world, and electrochemical industries which are likely to grow of greater importance with increasing knowledge of the electrochemical art.

When ground was broken in 1890 for the installation of the first great power plant at Niagara Falls, the engineers in charge of the project regarded the development of even fifteen thousand horse-power of electrical current with grave concern because at that time economical transmission of electricity over long distances was deemed hardly practicable and because the possibilities in the field of electrochemistry had been to only a slight extent foreseen. Except in the minds of a few, therefore, the utilization of any large amount of water from the Niagara River for the generation of power was held to be an undertaking of doubtful wisdom at best.

However, within a comparatively short time after the determina-

ONTARIO POWER COMPANY, NIAGARA FALLS, ONTARIO.



ONTARIO POWER COMPANY, NIAGARA FALLS, ONTARIO.

tion of engineers to install a large generator plant at Niagara Falls, discoveries were announced in the field of electrochemistry which if extensively developed would require the use of thousands of horse-power of electrical energy, and these discoveries encouraged the promoters of the great power project to believe that capital invested in the proposed plant would not be spent in vain. Moreover, the perfecting of an economical system of transmitting the electric current over considerable distances made it evident to engineers that very large quantities of Niagara power could be utilized commercially beyond the immediate vicinity of the power plants.

Two of the great power houses have been erected on the American side of the Niagara River somewhat over a mile from the crest of the cataract. In order to take advantage of the potential energy of the water and to afford an outlet for the water after its pressure has been used, two wheelpits were excavated out of solid limestone and shale about 177 feet deep, 18 feet wide and 450 feet long. Over each of these wheelpits was constructed a massive power house to contain the generators, switchboards, oil switches and other necessary apparatus. Extending vertically down the wheelpits to the depth of about 140 feet are hollow shafts to connect the generators on the power house floor with the turbines or water wheels below. Running parallel with each of the ten or eleven shafts in each power house is an immense pipe, or penstock as it is technically termed, of seven and one half feet in diameter through which water, after proper screening to remove ice and other obstructions, is conveyed from the intake canal to each turbine. After the large volume of water conveyed to each turbine, under an effective head of about 140 feet, dashes against the turbine blades, the water is disgorged into a subterranean tunnel about 21 feet in height and over a mile in length, through which the discharged water is conducted to the lower Niagara River, just below the abutment of the upper steel arch bridge.

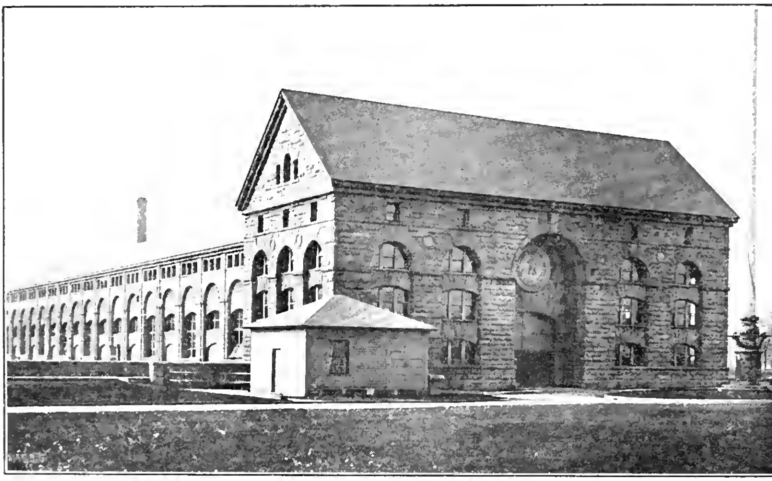
The turbines, by means of the shaft connection, cause the generators on the power-house floor to revolve at the rate of 250 revolutions a minute and to develop a two-phase alternating current of 5,000 horse-power.

Each generator with its connected turbine is entirely distinct from the other generators and turbines, and can be stopped by shutting off the water from the supplying penstock and by applying electrically operated brakes.

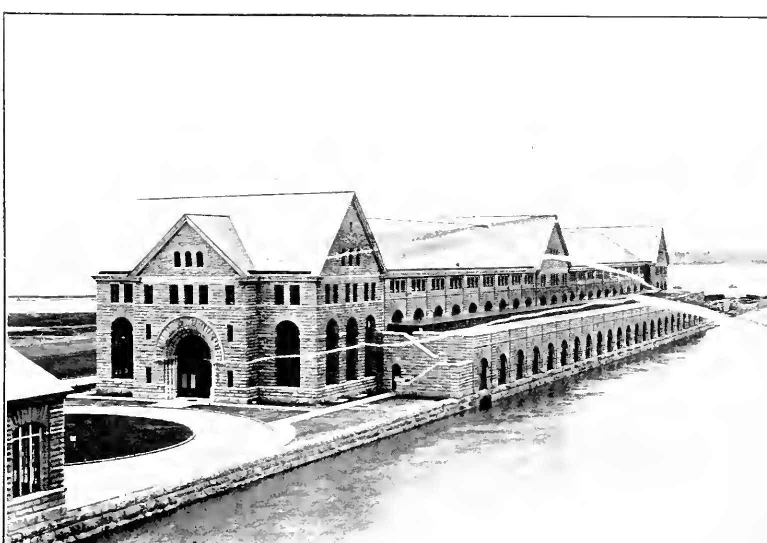
Practically, the whole tremendous weight of each generator, shaft and turbine is sustained by the hydrostatic upward pressure of water conveyed in separate pipes from the level of the intake canal to a compartment of the turbine wheel-case where the water presses against the lower surface of a disc secured to the shaft.

To generate an electric current by dynamos a coil of wire must cut the lines of magnetic force emanating from a magnetic field. It is immaterial whether the coils of wire (or armature) revolve around the magnetic field or the magnetic field revolves around the armature. For mechanical reasons, however, all the great generators at Niagara Falls are constructed so that their magnetic fields shall revolve about the coils of wire (the armature).

After the generators have developed the electrical energy the current controlled by appropriate switching devices is transmitted to the power tenants in the immediate vicinity and to the more distant tenants in Buffalo, Lockport and elsewhere. Where power is delivered to tenants within a short radius of the power plants, the current is transmitted at the generator voltage, but where power tenants are situated at such distances from the generators that electric current could be transmitted only at considerable loss at the generator voltage, it becomes necessary for economical transmission to increase or "step up" the voltage of the current by passing the electrical flow through transformers. A transformer by means of primary and secondary coils of wire of different diameters wound around a laminated iron core and with windings in a fixed ratio to each other may increase or diminish the voltage of a current according as an increase or a diminution of voltage may be necessary. The voltage of the current delivered in Buffalo is about 22,000, but as it would be obviously impossible to utilize so great a current pressure the electricity in Buffalo again passes through transformers where the voltage of the current is reduced to that required in the electric light and electric car service and for other power purposes.



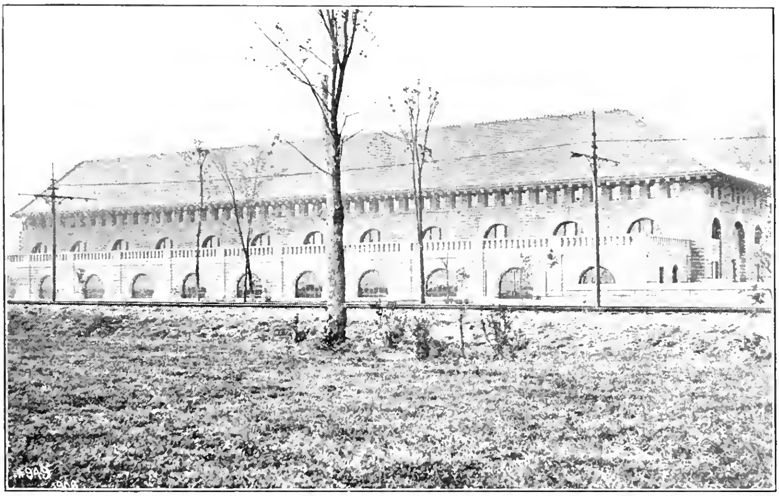
Power House No. 1, Niagara Falls Power Company (American side).



Power House No. 2, Niagara Falls Power Company (American side).

On the Canadian side of the Niagara River are three great power plants which are now generating about 160,000 horse-power, but which will ultimately develop nearly 400,000 horse-power. The Canadian generators are of much greater capacity than those on the American side and develop from 10,000 to 12,500 horse-power each. Two of these plants are built over wheelpits like those described on the American side and one of the companies in order to release the water used in its turbines has constructed *under* the Niagara River a tail race tunnel, the portal of which discharges directly beneath the Horse Shoe Falls.

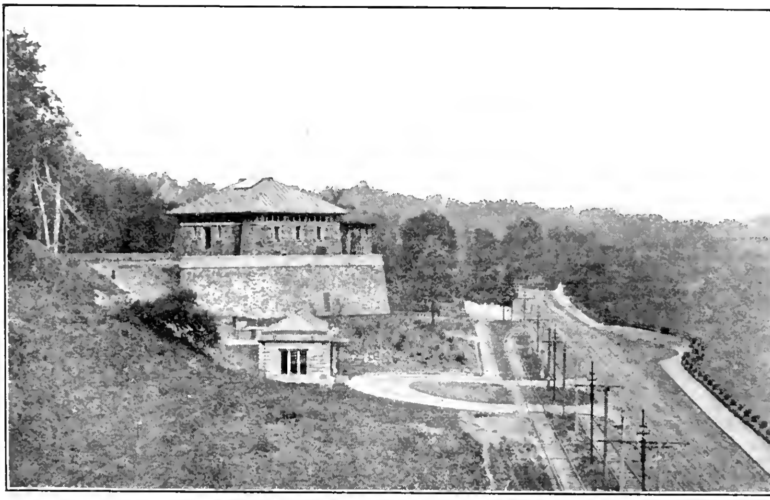
The Ontario Power Company by erecting a power-house at the level of the lower river and near the foot of the Horse Shoe Falls and by



CANADIAN NIAGARA POWER COMPANY'S POWER HOUSE.

conveying water through an eighteen-foot conduit from an intake canal above the falls has obviated the necessity and the great expense of building a wheelpit for the utilization of the water pressure and has acquired for its turbines practically the full head of water between the upper and lower rivers, a difference in level of approximately 175 feet.

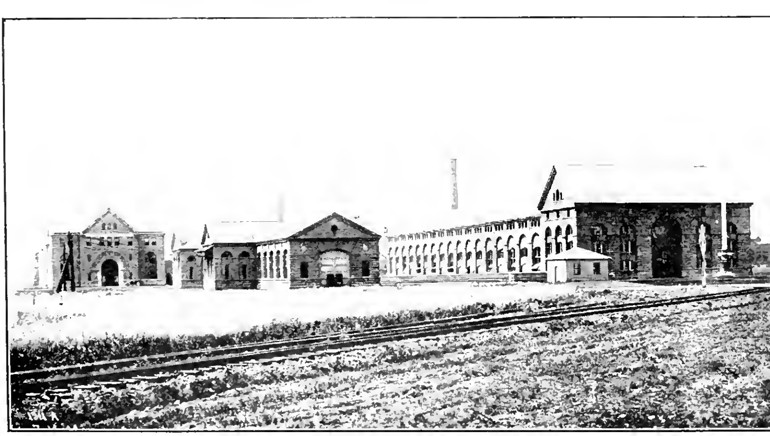
Directly above the Ontario Company's power-house the great eighteen-foot conduit is tapped by penstocks nine feet in diameter which convey the rushing water to the blades of the turbines. The generator attached to each turbine is thereby caused to revolve at the rate of 187½ revolutions a minute. Each generator weighs 231 tons and develops an alternating current of 10,000 to 12,000 horse-power at 12,000 volts, much of which is transformed to a voltage of 60,000 and transmitted with comparatively small loss over aluminum cables to Rochester, Auburn and Syracuse, a maximum distance of 160 miles.



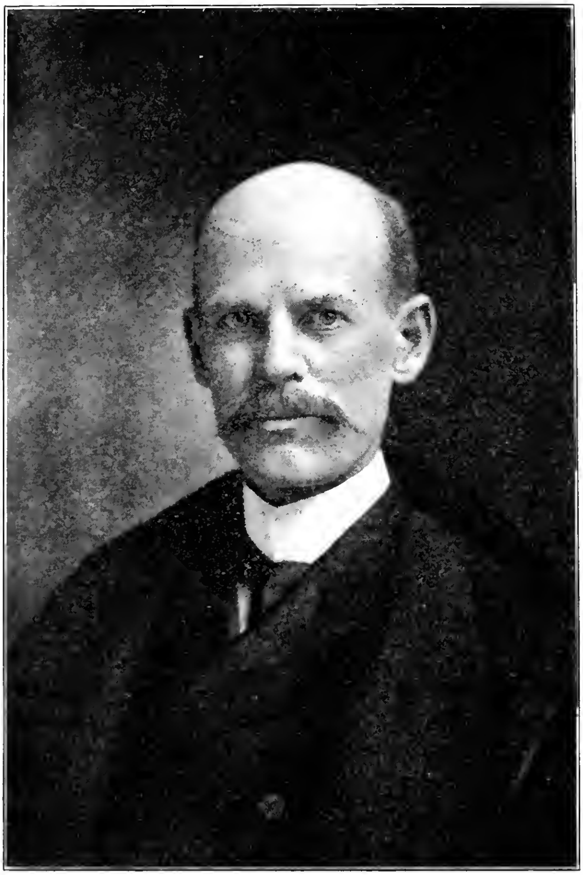
Entrance and Spillway House, Ontario Power Company, Niagara Falls, Ontario.

The uses to which electrical power is put in the city of Niagara Falls are most interesting. In 1886 Charles M. Hall, at the age of twenty-two and fresh from Oberlin College, devised a process for the inexpensive production of aluminum. Prior to Mr. Hall's discovery aluminum though the most abundant of all metals was united to other elements in such a way that a separation of the metal from its compounds was very difficult and correspondingly expensive.

Mr. Hall's process for obtaining aluminum from its ore is a reduction or deoxidation process by electrolysis. Into a carbon lined vat or "reducing pot" extend carbon cylinders. The vat is partly filled with powdered cryolite, a beautiful white mineral mined in southern Greenland. When the electric current passes, the resistance



Power House No. 1 and Power House No. 2 and "Step up" Transformer House in middle, Niagara Falls Power Company (American side).



Edward G. Acheson,
Discoverer of Carborundum, Artificial Graphite and Siloxicon.

to the passage of the current offered by the cryolite transforms into heat sufficient electrical energy to fuse the cryolite. Into the fused cryolite is poured calcined and purified bauxite in powdered form. The oxygen of the purified bauxite combines with the carbon of the anodes or positive poles of the electrolytic cell to form carbon monoxide and carbon dioxide gases and the aluminum is withdrawn in an almost chemically pure state. Since the cryolite serves merely as a solvent for the bauxite from which the aluminum is obtained and is unaffected by the electric current, the reduction of bauxite is continued indefinitely by pouring into the reducing pot enough bauxite to supply the place of that reduced.

Another electrolytic process in use at Niagara Falls is the production of caustic soda. The demand for caustic soda in many industries such as soap-making and paper-making is so great that an inexpensive way of producing this important alkali is imperative. The process is

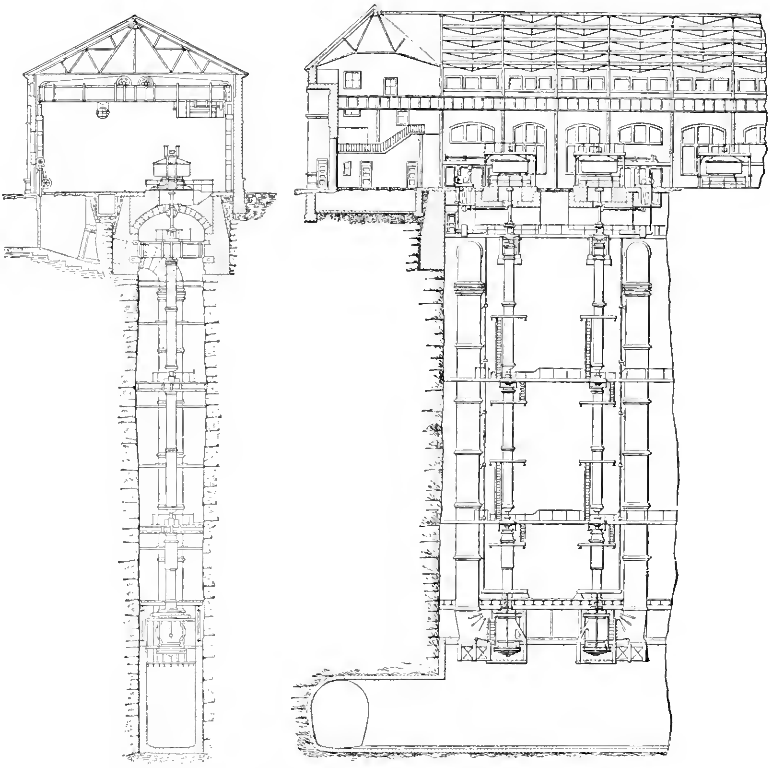
CHARLES MARTIN HALL.

Inventor of the Electrolytic Process for reducing Aluminum Ore.

comparatively simple. Into an electrolytic cell is poured common salt in solution. When the electric current passes through the brine the salt is separated into its constituent elements, chlorine gas and the metal sodium. The chlorine gas is evolved at the anodes of the cell and being led off combines with slacked lime to form chloride of lime or bleaching powder. The sodium unites or reacts with water to form sodium hydroxide or caustic soda.

When Moissan, the great French chemist, perfected the electric furnace he gave to scientists an easy way of producing a temperature which far exceeds that of ordinary fuel and even that of the oxy-hydrogen flame, and which made possible new and useful combinations and dissociations of matter obtainable in no other way than by the use of intense heat. The electric furnace is used at Niagara Falls in the manufacture of several new and important products.

Among the many recent discoveries in the field of electrochemistry

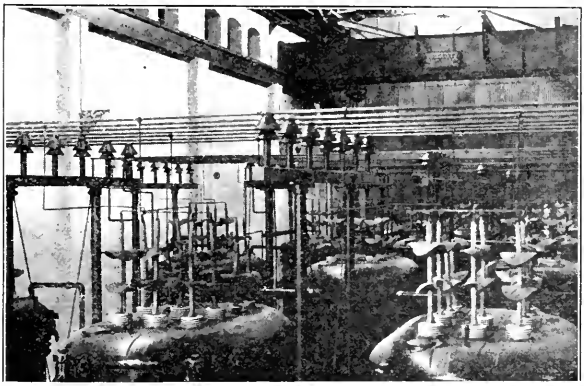


LONGITUDINAL AND TRANSVERSE VIEWS OF POWER HOUSES, showing wheelpits, generators, shafts, turbines, penstocks and discharge tunnels.

that of carborundum in 1891 by Mr. Edward G. Acheson is of great practical value. This new product is made by chemically combining in the intense heat of an electric furnace of the resistance type common sand and ground coke. After the charge has remained in the furnace for about thirty-six hours in a temperature of over 7,000° Fahrenheit, the resulting combination is found in a beautiful crystalline form. Carborundum ranks next to the diamond in hardness and is therefore used as an abrasive. In its so-called amorphous form it is used as a substance of great refractory power.

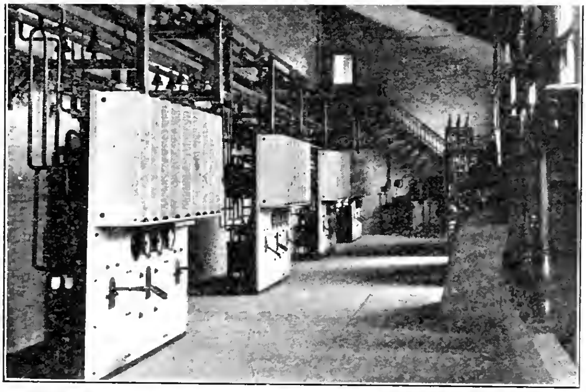
Metallic silicon, which is largely used in the steel industry to absorb the gases of the molten steel, is made at Niagara Falls by a deoxidation or reduction process. Ordinary sand and ground coke are intimately mixed and subjected to the heat of an electric furnace. The carbon combining with the oxygen of the sand is evolved as carbon monoxide gas; the residue is the element silicon in almost chemically pure condition.

Another of Mr. Acheson's useful discoveries is the production of graphite by artificial means. Graphite is carbon, but not the only form of carbon. Carbon exists in the amorphous form as in coal,



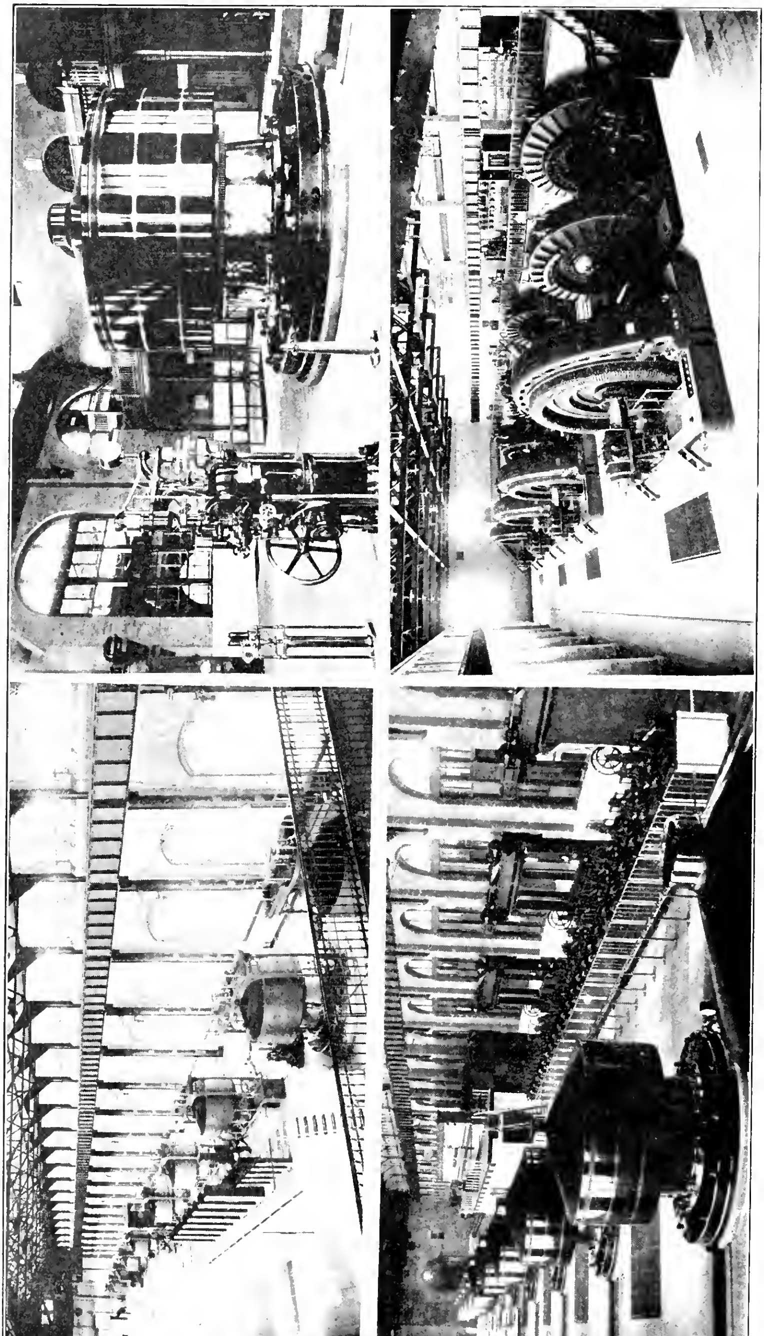
"Step up" Transformer Plant of Canadian Niagara Power Company.

Transformer plant of Niagara Falls Power Company.



11,000-volt Switchboard and Bars in "Step up" Transformer, plant of Canadian Niagara Falls Power Company.

charcoal and lampblack; in the crystallized form as diamond, and in the graphitic form as graphite. Until the discovery of a process for making graphite out of amorphous carbon the only source of supply



Interior Power House No. 1, Niagara Falls Power Company (American side).

Interior of Power House No. 2, Niagara Falls Power Company (American side).

Generator and Governor (oil pressure operation). Niagara Falls Power Company (American side).

Interior Power House, Ontario Power Company, Niagara Falls, Ontario, showing ten and twelve thousand horse power generators and double turbines.

lay in graphite mines such as those in the United States, England and Ceylon.

Artificial graphite is now made from any amorphous carbon which contains an admixture of some carbide forming substance and though other carbonaceous substances are used anthracite coal has been found to be the most satisfactory and economical carbonaceous material from which to make graphite.

Graphite is made by heating anthracite coal to a very high temperature, approximating 7,500° Fahrenheit. Into a long fire brick furnace is placed anthracite coal and through it a carbon rod passes. The heat generated by the resisted passage of the electric current through the charge is so great that practically all the impurities of the coal are volatilized, leaving its carbon content in the graphitic form.

Mr. Acheson has lately perfected a process whereby artificial graphite can be treated with gallotannic acid in such a way as to produce graphite so fine that it is well nigh molecular.

In the year 1892 it was accidentally discovered that if ordinary quicklime and coke were fused together, the resulting chemical combination would, by the addition of water, produce an illuminating gas of great brilliancy. The gas formed in this peculiar way is acetylene gas and the material from which it is generated is calcium carbide.

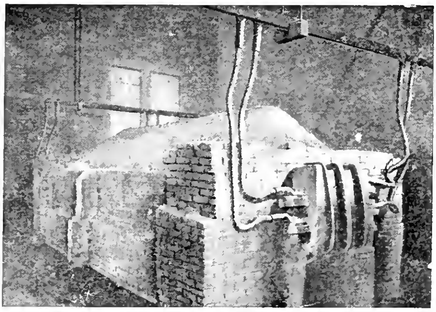
Calcium carbide is made at Niagara Falls by placing an intimate mixture of about three parts of powdered quicklime to two parts of powdered coke into an electric furnace of the so-called arc type. The current of electricity generates an intense heat which chemically combines the calcium of the quicklime with the carbon of the coke, the oxygen of the quicklime uniting with some of the carbon to form carbon monoxide gas which escapes.

It is interesting to know that the discovery of calcium carbide was almost simultaneously announced by two independent workers in electrochemistry, Moissan, the great French chemist, and Thomas L.

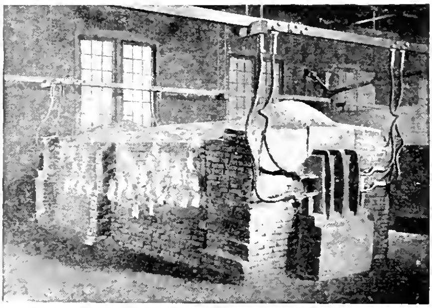
Eighteen-foot Conduit, Ontario Power Company, Niagara Falls, Ontario.

Willson, an American. Willson's discovery of calcium carbide, however, antedated Moissan's announcement by about six months.

At Niagara Falls are also to be found an immense paper mill which produces annually thousands of tons of newspaper made from



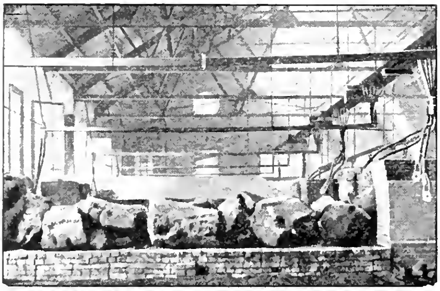
Carborundum Furnace with Charge ready for Heating.



Carborundum Furnace while Charge is being Heated, showing carbon monoxide gas issuing from side of furnace.

spruce logs reduced to the proper consistency by the mechanical and the chemical or sulphite process, a plant where lead is economically separated from its ore by electrolysis, a laboratory where vanilla and other natural extracts are successfully prepared by synthetic chemistry, and furnaces where bauxite is crystallized into an extremely hard substance for abrasive purposes.

From the foregoing survey of some of the industrial enterprises at



Carborundum Furnace with Walls removed after Heating, showing blocks of crystalline carborundum.

Electric Furnaces of the Resistance Type in which Artificial Graphite is made.

Niagara Falls it is evident that that region is a very important electric and electrochemical center and that it is destined to increase in importance with every new discovery in the electrochemical art.

THE CLASSIFICATION OF MATHEMATICS

By Professor G. A. MILLER
UNIVERSITY OF ILLINOIS

HERR VALENTIN, of Berlin, who has been working on a general mathematical bibliography for more than twenty years, estimates that the total number of different mathematical works is about 35,000 and that about 95,000 mathematical articles have appeared in the various periodicals.[1] The present rate of growth of this literature is so rapid that, without increasing the amount per year, the next fifty years would produce more than the total produced from the earliest records to the present time. Without some means of classification this vast store of knowledge would have little value from the difficulty of finding what is wanted. Before entering upon a description of any details of classification I shall make a few remarks on some of the terms of classification which are familiar to all; viz., arithmetic, algebra and geometry.

About three years ago Sir Oliver Lodge published an unusual work under the unusual title "Easy mathematics, chiefly arithmetic, being a collection of hints to teachers, parents, self-taught students, and adults; and containing a summary or indication of most things in elementary mathematics useful to be known." This title is followed by a no less unusual preface, whose tenor may be inferred from the following quotation: "The mathematical ignorance of the average educated person has always been complete and shameless, and recently I have become so impressed with the unedifying character of much of the arithmetical teaching to which ordinary children are liable to be exposed that I have ceased to wonder at the widespread ignorance, and have felt impelled to try and take some step towards supplying a remedy." The main reason for referring to this work in this connection is to call attention to what appears to be a very common use of the word arithmetic, as including most but not all of the mathematics which the average educated man should know.

Efforts to arrive at a much more accurate definition of the term arithmetic are apt to meet with disappointment. On the one hand, we meet with contradictory classifications among works of the highest authority. The great mathematical encyclopedia which is being published almost simultaneously in German and French includes determinants under arithmetic, while the *International catalogue of scientific*

[1] Felix Mueller, *Bibliotheca Mathematica*, Vol. 7 (1907), p. 416.

literature places determinants under algebra. If one were inclined to adopt the common definition that *arithmetic is the science of the relations existing between numbers,* one would be perplexed by the fact that the theory of groups of finite order is classed with arithmetic in the encyclopedia mentioned above, while it might be difficult to name any other mathematical subject which makes less direct use of numbers than this theory does.

Although these conflicting uses of the term arithmetic preclude the possibility of formulating a definition which is in accord with the usage of all of the prominent mathematicians, yet this term presents very much less serious difficulties than that of algebra from the standpoint of giving an acceptable definition. All are agreed that the four fundamental operations with natural numbers constitute a part of arithmetic. In fact, all that is generally studied in the elementary schools under the title of arithmetic is now universally regarded as a part of this subject, even if the Greeks called it logistica and dignified what is now generally known as higher arithmetic, or number theory, by the term arithmetic. While it might be difficult to find anything which was included under the term arithmetic during the entire historic period of mathematics, it is not difficult to find things which are now universally accepted as parts of this subject.

When we come to the term algebra, on the contrary, it seems impossible to find any common ground. If we think of algebra as a generalized arithmetic in which numbers are replaced by symbols which may have any numerical value, we are perplexed by such statements as "In arithmetic it is customary to represent any number whatever by a letter, it being understood that this letter represents the same number as long as the same subject is under consideration."[2] On the other hand, if one were inclined to consider the elements of the theory of equations as the peculiar sphere of algebra, the recent standard encyclopedia of elementary mathematics by Weber and Wellstein,[3] in which simple and quadratic equations are classed under arithmetic, would imply that such usage was not universal among eminent authorities.

Coming to the term geometry, we encounter scarcely less trouble. On the one hand, we find it advocated that geometry should be recognized as a science independent of mathematics, just as psychology is gradually being recognized as an independent science and not as a branch of philosophy,[4] while, on the other, we find that the Paris Academy of Sciences uses the term geometry as a synonym for pure mathematics. In the one case, the term geometry is used for what is

[2] "Encyclopédie des sciences mathématiques" (1904), p. 22.

[3] Published by B. G. Teubner, Leipzig, Germany.

[4] Bôcher, *Bulletin of the American Mathematical Society*, Vol. 11 (1904), p. 124.

not regarded as mathematics, and, in the other, it is supposed to comprise all that is generally included under the term mathematics. With such a wide range of usage among eminent authorities it is evident that an acceptable definition is hopeless.

These instances appear sufficient to emphasize the fact that the terms arithmetic, algebra and geometry have no definite meanings in mathematical literature. They may be compared with the names of the constellations, which attract the attention of the amateur but are not generally taken very seriously by the professional astronomer since their boundaries are not defined with clearness. Just as it may be difficult to establish a connection between the figures represented by the names of some of the constellations and the arrangement of the brighter stars in them, so it is difficult to see much connection between the meaning of the terms arithmetic, algebra and geometry, and some of the subjects classed under these heads. In a growing science it is very desirable to have some elastic terms—terms to which we assign broader and perhaps even different meanings as our knowledge advances. In fact, the term mathematics is itself preeminently one whose meaning is a matter of slow development, even if we accept such brief definitions as *mathematics is the science of saving thought,* or "mathematics is the science of drawing necessary conclusions."

The fact that many things which appear unrelated when studied superficially exhibit the most intimate connections when viewed from a higher standpoint has doubtless been a potent cause of the variety of usage as regards general terms of classification. There are no natural lines of division in mathematics. In fact, one of the most attractive phases in the development of mathematics is the discovery of the relations existing between what was supposed to be unrelated. In other words, the unifying of mathematical truths is one of the chief concerns of many of the workers in this domain. Although the elements of arithmetic, algebra and geometry appear sufficiently distinct to the beginner, the marks of distinction vanish one by one as one proceeds in following up the ideas starting from these centers, as is evidenced by the term analytic geometry, since analysis and algebra were synonyms for Newton, Euler and Lagrange.

Notwithstanding the fact that there are no natural lines of division in mathematics, classification is essential and need not be entirely artificial; for, marks of differences which are only superficial are, nevertheless, worthy of note and frequently furnish convenient centers for groups of very closely related ideas. Both subject-matter and method offer many such superficial marks of difference which are utilized for the sake of classification. As we go away from these centers we naturally reach facts which seem equally closely related to more than one center, and in such cases it is necessary to have either a duplicate or an artificial classification. For some purposes, such as arranging books on shelves in a library, the former is not feasible, and hence arises the constant opportunity of complaint on the part of those who use libraries with a view to obtain all available facts along certain lines. This opportunity is inherent in the subject and hence must exist under the most ideal conditions, but it is sometimes made more apparent by the fact that books are not always classified by those who are as familiar with the subject-matter as their authors were at the time of writing.

Although the present active period in mathematical development has exhibited many relations between subjects which appeared to be unrelated, yet it has been still richer in exhibiting new centers of developments which promise to be useful, and hence it has called for a great extension of classification headings, as may be seen from the 1908 edition of *l'Index du répertoire bibliographique des sciences mathématiques.* In order that a method of classification should give promise of usefulness for a long period of time, it must therefore be so constructed as to admit readily of indefinite extensions. This is a characteristic property of the two important methods of classification which have been adopted after international conferences, viz., *l'Index du répertoire* just mentioned and the International Catalogue mentioned above. The former of these provides for an indefinite extension of its fundamental headings by using the capital letters of the Roman alphabet with various exponents to represent these headings. On the other hand, the International Catalogue divides all mathematics into four parts, in addition to a general heading for history, periodical, general treatises, etc.

In the first five annual issues of the International Catalogue these four parts into which all mathematics is divided bore the following headings: Fundamental notions, algebra and theory of numbers, analysis, and geometry. In the last issue of this catalogue the first of these headings is replaced by arithmetic and algebra, in accordance with the decision of the international convention of 1905. The term algebra now appears in two of the four headings, and, if it is remembered that the theory of numbers is higher arithmetic, this term is implicitly in two of these four headings. This is another evidence of the vagueness of the terms arithmetic and algebra as used in some of the best mathematical literature of the present day, and seems to imply that these terms, especially the former, are more and more devoted to those fundamental notions which are most prominent in the later developments, or have the most frequent uses in related sciences. As the science grows some things which are now classed with analysis or geometry will naturally be put under other headings.

While it might be impossible to advance good reasons for dividing mathematics into exactly four grand divisions, yet a small number of divisions offers advantages by furnishing names which will generally be remembered and by emphasizing the connection between extensive developments. It is true that the names of these grand divisions do not have a very definite meaning, but they have some meaning, and they exhibit something of the tenor of the various branches whose names are too numerous and appear too erudite to the average educated man. Instead of simply saying that one is working on Ausdehnungslehre it may be some satisfaction to add for the benefit of the uninitiated that this is a kind of algebra, and thus established language contact even if thought contact is out of question.

A question of more general interest is the number of parts into which mathematics is divided in the final classifications. The answer to this question gives some idea of the fractional part of the entire literature which must be examined by one who is seeking all that is known along a particular line. The last issue of the International Catalogue contains only about two hundred headings, so that one would have to look over one two-hundredth of the total publications of the year in order to find all that had been written during the year on a subject comprised under a single heading. In this respect *l'Index du répertoire* is much superior. In fact, the last number of the *Revue semestrielle des publications mathématiques,* which follows this index, classifies the publications under about seven hundred headings, and, as a large number of headings have no entries during one of the periods of six months, it would frequently be possible to get at all the literature which appeared on a particular subject during a period of years by examining less than a thousandth part of the total mathematical literature of the period.

The preceding paragraph relates to the classification of current literature. The classification of the total literature is in a much less satisfactory condition. The magnitude of this work may be inferred from the facts that Müller's *Mathematisches Vocabularium* contains more than ten thousand technical terms used in pure and applied mathematics and that it is not exhaustive. As most of these terms relate to concepts which either are or may become the centers of a series of closely related developments, we can predict no limit to the number of headings under which the mathematics of the future will be treated. In fact, if we adopt the view that mathematics consists of creations as well as of discoveries, considerations as to limits become very vague even if they do not lack interest.

Professor Sylvester once called himself the mathematical Adam in the proud consciousness of having named a large number of algebraic concepts and that these names had become more or less current among his colleagues. While technical terms are useful for the sake of classification yet the number of such terms may become so large as to justify the criticism of Hankel that the stately mathematical structure resembled the tower of Babel. The proper time for the introduction of new technical terms and new heads of classification must depend upon the good judgment of the workers in this field, it being remembered that terms and classifications are secondary matters, although by no means useless, and that the main thing is to extend the domain of knowledge, especially where the beauty or usefulness of the results assure them a permanent place in the intellectual wealth of the world.

A large variety of classifications may prove serviceable to the investigator. Sometimes an author's catalogue may render the best service, while at another the grouping together of a large number of related things as is done in the *Jahrbuch über die Fortschritte der Mathematik,* where pure mathematics is divided into only fifty parts, renders the most valuable service. At still another time, the dictionary arrangement under thousands of terms, as it appears in the indexes of large works, especially in the incomplete encyclopedia to which we referred above, offers the most convenient method of arriving at the desired information. Fortunately the current mathematical literature is now being classified according to several different methods, each possessing peculiar advantages for the different needs of the scholar.

The history of classification in mathematics is very old as may be seen from the fact that the mathematical handbook of Ahmes, which was written about 1700 B. C., already contains the divisions into arithmetic, and plane and solid geometry. As this work bears the title "Directions for obtaining a knowledge of all dark things," it would appear that the observance of the distinction between arithmetic and geometry may have been older than of that which separates mathematics from the other sciences. In fact, even at the time of Plato, the term mathematics included all scientific instruction and its more restrictive meaning seems to have had its origin in the Peripatetic School. The main divisions of the mathematical sciences during the Greek period were: logistica, arithmetic, plane and solid geometry, music and astronomy. One of the best known classifications of mathematics is the Quadrivium of Boethins, viz., arithmetic, music, geometry and astronomy; and it is an interesting coincidence that the International Catalogue should have established a quadrivium of pure mathematics, as was observed above.

Among the general terms of classification, that of analysis is probably the least familiar to the non-mathematician. All have some idea of arithmetic, algebra and geometry from the context of elementary text-books bearing these names, but it is not customary to place the term analysis on the cover of an elementary text-book in the English language. Perhaps this is due, in part, to the fact that our secondary mathematics does not generally involve the concept of derivative, which was introduced into French secondary instruction in 1902, and has proved successful in that country as well as in some others where it has been tried. From a historical point of view analysis is merely an extension of algebra. It has already been observed that for Newton, Euler and Lagrange analysis and algebra were synonyms, and the present significance of the term analysis may be inferred from the fact that the most familiar subjects that are now generally comprised under it are differential and integral calculus and the theory of functions.

It may be desirable to add that the aim of the present article was to convey some idea of the extent and nature of the modern mathematical developments, from the standpoint of classification. While this standpoint reveals only the outside yet this side is worth knowing and is apt to awaken some thoughts in regard to what may be within. As the use of machines has revolutionized the material world, so the use of mathematics has revolutionized the efficiency of thought in regard to problems whose solution is sufficiently elementary to come under known developments. As these developments proceed they provide for greater efficiency and wider applications. The analogy between mathematics as a machine of thought and an ordinary labor saving device known as a machine can be traced through many points of interest. It should, however, be emphasized that the real mathematician is the inventor of such machines, but not the machine itself.

ACADEMIC ASPECTS OF ADMINISTRATION[1]

By Professor JOSEPH JASTROW
UNIVERSITY OF WISCONSIN

THE community of spirit that animates such occasions as this is an interest in the academic life—a conviction, studied or casual, sincere or perfunctory, that much of what makes life worthy has its source here. What more appropriate than to discuss the *status quo,* with a view to discover what forces are making for and what against the vital concerns of academic welfare?

Psychologically, I can not endorse the platitude that silence means consent. As I have tried to interpret this eloquent if enigmatic expression, it has appeared to mean complacency, even indifference; it means hesitation and timidity; it means expediency and temporizing; it means torpidity or denseness of understanding. Hence the way of the reformer is hard. It is upon that ill-paved road that I am to venture, and with no other warrant than a common interest, to invite companionship.

The general silence in the academic ranks is hardly a convincing proof that all's well; nor is the silence wholly unbroken. The literature of protest is growing; and the murmur of discontent may be plainly heard by the sympathetically attuned ear. To appreciate the atmospheric conditions that prevail in the academic grove and that at times impress and oppress the dwellers therein with the suspicion that they have inherited a vale of tears with a bad climate, requires some familiarity with the general features of the habitat. To begin with, the grove itself is no longer the peaceful retreat amid cloistered walls and quiet walks, to which the bookish fancy of the uninitiated and the impervious imagination of the reporter are so fondly attached. The trolley clangs by its portals; the noise and dust of the city pervade its corridors; the unhedged campus is criss-crossed by throngs of eager invaders seeking a short-cut to learning. The guileless, absent-minded, root-grubbing professor, absorbed in profitless didactics, survives only in those lingering echoes of receding ages—the comic papers. The American professor desires to live in the world and to assume responsibilities and privileges according to his capacity. He cherishes ideals not of scholarship alone, but of service—worthy, dignified, and by higher standards profoundly useful. Compositely

[1] An address at the Collegiate Conference in connection with the seventy-fifth anniversary of Oberlin College, June 24, 1908.

(I ignore the pardonable exception of those still overawed by their own doctor's dissertations), he entertains no illusion that the fate of culture rests in his hands. He recognizes the many forces that sympathetically with his own endeavors are making for a common goal. He recognizes with deep concern the many other groups of influences that display the lure of cheap success, that crowd out the nobler, calmer virtues by an insistent demand for immediate returns, and bring the money-changers back into the temple of learning. Thus coming to his own, looking backward for the benefit of experience, looking inward for the illumination of what might be, he is emboldened at times to look forward to a future in which shall be more freely realized the career that he cherishes, to a release in greater measure from the hampering restrictions amid which he has become resigned to adjust his own service.

A sensitive barometer of the academic atmosphere is to be found in what we have learned from the Germans to call *Lehrfreiheit;* but which as made in Germany is by no means a cheap article or easy to secure. This delicate instrument must be adjusted to each climate; and to read its indications is something of an art. The facetiously inclined like to repeat the dictum that Boston is not a city, but a state of mind; but so is every locality with a title to distinction. America is a state of mind; the university reflects, fosters and imbibes states of mind. The state of mind marked on the intellectual map as academic freedom is difficult to localize. One is tempted to say that it is bounded on the north by the overshadowing mountains of the check-book, on the east by the tidal waves of current opinion, on the south by the chain-and-compass survey of past generations, on the west by the undrained marshes of political venture. Its contours are evasive and shifting. It is best recognized by the cultures it favors and by the serenity and charm of its landscape. The condition it implies is much more than the untrammeled freedom to teach fearlessly what reason finds true or holds plausible. It is a declaration of the right of this domain to develop its own academic life, academic liberty and academic pursuits of happiness.

The university's conception of its own function and the development of men and measures to further its own aims, naturally and properly reflect, as they have ever reflected, age and people and condition. But loyalty to its own ends as conceived with such wisdom as the leaders of men could command, was and is indispensable to the academic life. The purpose must be large, the service comprehensive, the honors worthy, the career attractive to enlist the life-long devotion of ability, character and ambition. The loyalty concerned flourishes only when those who bring it feel themselves spiritually akin with the larger life with whose fortunes they have linked their own. It is because old-time and old-land universities embody such traditions of loyalty and service that we, so distant in our pursuits, yet wander with profound appreciation in their ancient halls.

But we are modern of the moderns; and nothing is more characteristic of our heritage of all the ages than the critical analysis with which we plan and conduct our efforts. The sense of the comprehension of progressive motives and rivalry of influences has been deepened, indeed reconstructed, by the insight into evolutionary procedure that reached its first articulate expression just fifty years ago. The obligation of such insight is the duty to inquire into the forces which we shall strengthen and which antagonize, that we may remain masters of our fate. The evolutionist is neither a fatalist nor a stand-patter; he sees, foresees and directs, and he does this with the sobriety resulting from an historical conscience, and with the faith in the privilege of rational leadership. We of the academy accordingly hold to the law of the grove; that a university ancient or modern is wholly and vitally an educational institution; that the aims for which it exists are cultural; that its methods must be shaped by its own standards; that the activities of those devoted to its welfare must be freely developed from within and suitably to the cultivation of the ends for which the university alone exists. Reduced at once to its lowest and to its highest terms, the university is and can be nothing else than an assemblage of men united in the sympathy of pursuit and inspired by community of interest and a common loyalty. That the university shall attract such men and find in them the medium of her purposes, and that such men shall seek the university and find in her the enduring incentive to their best endeavors: this is the ideal that serves as the criterion of the worth of practical measures which now we approach.

We, the American people, have developed or accepted a type of university administration, to which there is no close, hardly a distant, parallel elsewhere. On a former occasion, having in mind the somewhat harsher aspects of the system, I called it government by imposition. Professor Stratton has since then proposed the more acceptable term, externalism. It is then a well-known fact that our universities are governed by boards of trustees or regents, with complete legal authority over the measures proposed by the faculty, over the status of the professors individually and collectively, and always indirectly, usually directly, over educational policies, over the larger complex issues that determine the spirit and the conditions of university advance, and naturally over the ways and means contributory to the realization of all this. In many institutions no act of the faculty is valid unless confirmed or reviewed by the board. For example, so irrelevant an issue as a case of student discipline sends an appeal to the board over the heads of president and faculty, with the not infrequent result that there is imposed on the faculty by direct command of the board tedious and humiliating reexaminations of a situation already properly disposed of by suitable committees. The formal statement that educational matters shall be in the hands of the faculty is for the most part evasive or ineffective. Since most matters have both aspects —financial and educational—and since the faculty can not or does not determine what measures it prefers to consider, its influence in these directions varies from a conceded control so long as no opposition is evidenced, to something merely nominal.

Such externalism of government more than any single influence has brought about the growth of another peculiarly American institution—the university president. I need not enlarge upon the heroic proportions which this majestic figure has assumed among us. It has led a professor, sympathetic with the present plea, to say that the American university has a Brobdignagian president and a Liliputian faculty. Professor Stratton regards the organization as derived from that of a colonial corporation—the financial control reserved by an absentee board in the home country, and the president representing the governor sent to the colony to direct its concerns. This historical setting may invest the organization with some interest, but it can not divest it of its dangers, nor does it account for its continuance and emphasis. Let me cite from the article to which I refer: In a country that politically is most jealous of democratic rights, "university government has assumed a form that we might have expected to see in a land accustomed to kings. European universities have a constitution that might have come from some American political theorist; American universities are as though founded and fostered in the bourne of aristocracy." "The American university president holds a place unique in the history of higher education. He is a ruler responsible to no one whom he governs, and he holds for an indefinite term the powers of academic life and death." "The polity that we might call monarchic is thus not only frequent in the new-world colleges, but it is stripping away the few lorn shreds of popular control which still remain among them."

The state of mind that has entrenched this unsuitable form of government so securely may readily be analyzed. The factors contributory to the result are several and diverse. There is a peculiarly democratic distrust of the man who knows. To call a man an expert is almost sufficient ground for a suit for libel. Conversely there is the glorification of the man who does, without too close examination of the merit of what he does and how he does it. Our captains shall be captains of industry. Business acumen in the popular mythology is Jupiter and Mars and Vulcan compositely, and properly lords it over the affairs of Athena and even of Venus. The Olympian council comfortably settled in revolving chairs in the lofty seclusion of a skyscraper summons

Apollo to make his report and engages the Muses at modest stipends upon condition of good behavior. But in truth there is no danger that the very important services of liberal-minded men of affairs to the maintenance of our universities will go unrecognized. The association of such a body as a board of cooperation is at once high token of regard for a high type of citizen, and is of definite benefit to the institution concerned. This contribution of external cooperation is quite in keeping with the genius of our national practical sense. The great and overwhelming misfortune is that its function has been so wholly misunderstood in the light of legal authority and of a popular conception growing out of relations in the business life wholly unrelated to what must and should obtain in the academic world. When the board recognizes that the university is not a business concern; that it has laws of its own; that the faculty alone can determine the mode of advance within the university, that the position of a professor is that of a counselor, free, authoritative and independent, there will be no externalism in the objectionable sense, but only external cooperation. American conditions are individual. We can not copy either the English or the German mode of government. We can secure our own type of efficiency without sacrifice of what is the essential end of all institutions of learning. Hence boards have their place, but a place determined by the subservience to the cultural ends of the university, which must ever be paramount. Business procedures must be secondary to educational ones; those who control the former should not in the least control the activities, status and decisions of those entrusted with the educational conduct of the university.

Dominated by this business view—even in its comparatively enlightened form—comes an imperious demand for results, tangible, visible, audible to the popular sense. The curve of the annual freshman crop must not compare unfavorably with that of the other indigenous products of the soil; new departments with smart heraldings must be added; the catalogue must put on pages of adipose tissue; the campus must suggest the inspiring appearance of a western town site. If a stranger had been present at a memorial exercise which I have in mind, he would have concluded that the deceased had been a mason contractor and not a college president. The addresses dwelt with loving fondness upon the buildings erected during the administration, giving the area of the floors in square feet and the cost in dollars. Now quite apart from the conspicuous and vulgar extremes of this attitude, let it be acknowledged in a meek confessional spirit that enough of it obtains in the best of our institutions to decidedly guide the direction of activities and warp them away from the path of true academic progress. This factor helps to account for both externalism and the exaggerated contours of the presidential silhouette.

As thus analyzed, the situation is explicable, in part even justified. As evolutionists we bear in mind the rapidly shifting, indeed the unprecedented character of the conditions in which our academic practises have been evolved. Under such conditions organization must be elastic, initiative open, adjustments ready to meet emergencies. Power is naturally concentrated in a few, even in a single hand; and once more, the democracy of our ideals asserts itself in the keeping in touch with popular demands of what academic service may be expected to supply. But it is still more true and very much more significant, in so far as this is an excuse, that we have outgrown all that, except where the frontier still holds. The time is here for most of our universities and is close at hand for the rest, when we must cease to ask special consideration for our educational provisions. We are not a weakling nor an unfortunate people. Let our universities stand as worthy embodiments of our national resources comparable with those of other lands, as do our railways, our factories or our public library system. This is not a matter of time, but of tradition. Some of the foremost of the German universities are about as old or younger than the college whose anniversary is now observed. But the traditions under which these were established and under which they have developed are decided traditions of the supreme right of *Lehrfreiheit* and of the great distinction and worth of the academic career. If such is to obtain amongst us we must develop perceptions keen to that which is educationally sound, to what is culturally good; we must trust implicitly those who have these perceptions; we must secure for the career devoted to this cause, honor, encouragement, responsibility, authority and a suitable living.

From whatever side we approach the situation we reach the same conclusion, for the factors thereof are of a nature all compact. We measure academic success by unsuitable standards, derived from the market-place; and as a consequence there is a sorry contamination even within the fold. That the professor has not been able to withstand these several influences must with like frankness be confessed. The law of the grove is compromised, evaded or forgotten. Professors become statistically minded, dwell upon sizes of classes, offer inducements for the hesitant student, seeks the favor of those in power and further the ends preferred by those who mete rewards. We find them also discouraged by the unfair struggle for existence, with everything rising except the price of postage stamps and professors' salaries; we find them acquiring a disturbing interest in commercial ventures; we find them losing the finer qualities of their service because of the trying elements in the intellectual climate. The excuse is not far to seek. When men of the academy find, as years go by, that their own preferment is largely determined by utility, not in direct development of their personal ability; their activities too constantly dominated by an oppressive sense of accountability; when even their bread and butter is imperiled; when they are subjected to the humiliation of having others pass them by who have yielded where they have stood steadfast, who is there shall cast the first stone?

I had hoped to carry through my purpose without once more exposing the collegiate family expense account to the patronizing scrutiny of the affluent public. But, alas! it may not be. Bear with me in a brief "aside." The lack of proportion between the professor and his salary is regrettable yet remediable. More regrettable and I fear more difficult to remedy is the mode of determination and adjustment of such honorarium. Yet in this as in all related adjustments enlightenment is to be found in the common principle of academic supremacy. Here more than anywhere else must commercial encroachment and standards be resisted, not meekly, but strenuously. It seems plausible that if an incumbent of a professional chair is worthy to sit in the cathedra, he is worth the provision of a suitable living. The professor must not ask more nor for other reasons; the university must not offer less nor guide its offer by extraneous considerations, least of all of those that obtain in the auction room or the stock market. Professor Palmer says very plainly that Harvard University pays him for doing what he would gladly pay the university for the privilege of doing; and most professors pay and pay dearly for the privilege of the academic life. So let it be. But persistently and evasively are academic standards ignored, and ignored by those who do and those who do not understand. All honor to the few—alas the very few colleges, but among them the worthiest in the land—that have retained an academic adjustment of salaries. In the main, the influence of the college presidents has in no direction been more baneful, more insinuatingly subversive of what other merit their services have brought, than in this practise of speaking of supply and demand, the meeting of emergencies, the offset of a call from another institution, and a spurious attempt to apply a doctrine of merit and prizes. When a university president regards himself—a mere mortal—as capable to translate academic worth into dollars and cents even to the fraction of a dollar per weekly wage, I do not know whether to regard his position as an educational alchemist as sublime or ridiculous. I confess that it is astounding to me that men in this position, of such high attainments, such clearness of vision and sterling virtues, should maintain such a large and efficient blind spot when contemplating the salary question. Many a fellow professor in the mellow confidence of a growing intimacy has confided to me that he looks upon the attempt to apply such a procedure to himself as a farce, an affront or an evasion. Usually it is the last; for the answer given to Professor A is not that given to Professor B; while Professor C, but recently refused recognition, finds that his merit has risen several points because his stock is quoted higher at a rival university exchange. Not thus is academic loyalty furthered. The salary question is a most disturbing factor of the academic situation; and the cure is prevention. Most of the irritating situations must not be allowed to arise; the ones that legitimately find their place will be suitably solved under a suitable system of principles; and the president's life, if he wishes it, will be a happier one. An equalized system of comfortable salaries fixed for the professorship and the scale of living of the environment, will dispose of this question and leave all freer to devote themselves to what their functions demand. I do not advocate for the good of the academic life the existence of large rewards or special prizes, though I deem it for the good of the community to thus manifest its appreciation of academic service. I agree with President Remsen that once the professor is relieved from financial worry the cause would not be particularly benefitted, though the professor might be pleased to receive a larger income. It is thus clear that the procedure by which incomes are to be determined and adjusted follows directly from the principles that show the way to remove far more difficult though not more irritating disabilities of the academic life.

President Remsen's remark laid him open to a retort which was promptly made: that a president would not be injured though he might be pained by having his salary reduced to that of a professor. The disparagement between the appraisal of academic and of administrative service is yet another and a serious misfortune of externalism. It affects not presidents alone, but deans, and heads of departments; it diverts unusual talents into unprofitable channels; it obstructs many of the byways of academic activity. It is thoroughly bad in appearance or reality to countenance the view that the only or the normal method of rising is by assumption of administrative powers. It is equally bad to encourage the popular misconception of academic service by throwing the limelight either upon administrative position or upon athletic prowess or upon any but the central purpose for which the university exists. It was far different in the older simplified college, in which the president was commonly the leader of the faculty, the embodiment of the spirit of the institution, distinguished for just what the academic sanction of the day approved, and quite incidentally an administrator. To-day when the office seeks the man, the search is for one with executive taste or pioneering ambition; and when the man seeks the office, it is too commonly because he likes the disposition of authority and the enjoyment of movement with no oversensitiveness to the jar or other disquieting accompaniments of locomotion. I do not for a moment imply that the university presidency is other than a most honorable career, or that the incumbent should set aside the honorable satisfactions of high office. I do imply that a president who in any way uses the university as a means of personal exaltation is abusing his office; I do imply that such success even when most deserving and well directed is too dearly bought when it is paid for, as commonly it is, by the mutilation of the academic efficiency, often the personal unhappiness of many a professor. I imply more than this: that the spirit in which the presidency should be assumed is not wholly different from the attitude which I heard a progressive American demoiselle prescribe for her mother as a most effective way to encourage the social success of her daughters; namely, to efface herself except when summoned. Now I am not approving this rule of conduct; I am but suggesting that a large measure of this spirit of depersonalization, somewhat more loftily conceived, shall dominate all who serve the administration of the grove. Administration must ever be second; and often must it be last. Academic perspective can be retained only by an advancement to the foreground in every presentation of scientific insight, educational wisdom and commanding personal quality, by the retirement to the background of all auxiliary services however essential, difficult or worthy, so that those within and without shall see, hear and understand. Once more let me cite the testimony of another (Stratton): "We exalt administrative ability above scientific insight," which should not be. Universities "should be the last to typify in their own structure the thought that discovering truth and imparting the vital principle whereby others may discover it are of a dignity less than that of organizing and management."

I can not better reenforce the scattered contentions of my plea than by gathering a few citations from one and another who, surveying the same sets of influences in which as it seems to me lies the future strength or weakness of the American universities, have brought away a similar and even less hopeful outlook. Professor Cattell regards with special concern the autocratic domination that externalism brings and the deterioration of character that follows in its wake:

> The individual has once more been subordinated, crudely commercial standards prevail, and control has been seized by the strong and the unscrupulous. Those of us who are not ashamed to express faith in democracy regard all this as a temporary phase, which will only last until intelligence has developed equal to the complexity of the environment. The only real danger is that instincts may become atrophied before reason is ready to take their place. The trust promoter and insurance president, the political boss and government official, the university president and school superintendent, have assumed powers and perquisites utterly subversive of a true democracy. The bureaucracy is defended on the ground of efficiency; but efficiency is not a final cause. To do things is not a merit regardless of what they are, and bigness is not synonymous with greatness. There is no ground for hopelessness. Of the things done the good may last and the rest may be eliminated; bigness may become greatness.

Yet this tinge of hopefulness tends to fade when the same writer records that the

Czar of Russia has restored to the professors the right to elect their rectors and deans at the same time that the trustees of one of the largest American universities have taken the vested right to elect their deans from the faculties without even asking their opinion or communicating to them their fiat.

The same writer says:

The administration imposed on universities, colleges and school systems is not needed by them, but simply represents an inconsiderate carrying over of methods current in commerce and politics. The private institutions of the east, with Chicago and Stanford, have been dependent on gifts from the modern knights of industry, and the state institutions have been dependent on legislative appropriations. It is no wonder that the methods of commerce and politics have infected them. We have an absolute and absentee board of trustees, with sometimes a small group that takes an active interest in the situation, but usually an almost complete delegation of legislative, judicial and executive functions to one man, the president. When the wisdom of letting a man lord it over an aggregate of employees instead of conferring with a company of scholars is questioned, the answer is the efficiency with which the autocrat gets things done. The president gets money and students, and builds marble palaces. . . . The marble palaces may be mausoleums for the preservation of the corpses of dead ideas and monuments erected to the decay of learning.

Another student of the field—not a professor—wholly disinterested and surely unprejudiced tells us that

Young men of power and ambition scorn what should be reckoned the noblest of professions, not because that profession condemns them to poverty, but because it dooms them to a sort of servitude.

And again:

Unless American college teachers can be assured that they are no longer to be looked upon as mere employees paid to do the bidding of men who, however courteous or however eminent, have not the faculty's professional knowledge of the complicated problems of education, our universities will suffer increasingly from a dearth of strong men, and teaching will remain outside the pale of the really learned professions. The problem is not one of wages; for no university can become rich enough to buy the independence of any man who is really worth purchasing.

Lastly I shall cite at length and should like to cite in full a notable editorial in the *Dial*. The writer notes, as do others, that the vital difficulty lies in our mode of thinking about these problems:

Material and commercial modes of thinking prevail so largely in our national consciousness, and impose themselves so masterfully upon our narrowed imagination, that most people are ready to accept without hesitation their extension into the domain of our intellectual concerns, particularly into that of the great concern of education. Why, it is naïvely asked, why should not the methods that we apply with such pronounced success to the management of a bank or a railway prove equally efficient in the management of a system of schools or a university? . . . These questions are not difficult to answer but it is difficult to frame the answer in terms that the successful man of affairs will find intelligible. The subject is one that he approaches with a prejudiced mind, although his bias is not so much due to a perversity as to sheer inability to realize the fundamental nature of the question at issue. He is so fixed in the commercial way of looking at organized enterprise that he can not so shift his bearings as to occupy, even temporarily, the professional point of view. Now the idea of professionalism lies at the very core of educational endeavor, and whoever engages in educational work fails of his purpose in just so far as he fails to assert the inherent prerogatives of his calling. He becomes a hireling, in fact if not in name, when he suffers, unprotesting, the deprivation of all initiative, and contentedly plays the part of a cog in a mechanism whose motions are controlled from without. Yet the tendency in our country is to-day strongly set toward the recognition of this devitalized system of educational activity as suitable and praiseworthy, and the spirit of professionalism is engaged in what is nothing less than a life-and-death struggle. When a university president or a school principal can indulge unrebuked in the insufferable arrogance of such an expression as "my faculty" or "one of my teachers," when school trustees are capable of calling superintendents and principals and teachers "employees," it is time to consider the matter somewhat seriously, and inquire into the probable consequences of so gross a misconception of the nature of educational service.

There is one general consequence which subsumes all the others. It is that young men of character and self-respect will refuse to engage in the work of teaching (except as a makeshift) as long as the authorities in charge of education remain blind to the professional character of the occupation, and deal with those engaged in it as objects of suspicion, or, at best, as irresponsible and unpractical theorists, whose actions must be kept constantly under control and restricted by all manner of limitations and petty regulations. Membership in a profession implies certain franchise, an emancipation from dictation, and a degree of liberty in the exercise of judgment, which most members of the teaching profession find are denied them by the prevalent forms of educational organization. And the denial is made the more exasperating by the consciousness that these rights (which are elementary and should be inalienable) are withheld by persons whose tenure of authority is more apt to be based upon the executive energy or the ability of the schemer or the success of the man of practical affairs than with expert acquaintance with the conditions of educational work. The "business" president or administrative board is bad enough, and the "political" president or board is worse; yet upon the anything but tender mercies of the one or the other most men who devote their lives to the noble work of teaching must in large measure depend.

The inevitable consequence is . . . to make the teaching profession more and more the resort of the poor in spirit, to whom the words of the Beatitude must have a distinctly ironical ring. To become a teacher in this country is, except in the case of a few favored institutions or systems, to subordinate one's individuality to a mechanism, and to expose one's self-respect to indignities of a perculiarly wanton sort. Inadequate compensation is a grievous fault of our educational provision, but it is not so grievous as the faults that undermine professional self-respect, and sap educational vitality at its very root. Yet these graver faults are easily remediable, and would be promptly remedied if we could once rid ourselves of the obsession of the commercial or military type of administrative organization.

These earnest words of endorsement and appeal will serve at once to make it plain that the issue upon which I speak is a most serious one, and that I look upon it with no extreme or wholly individual obliquity of vision or personal despondency. I feel, indeed, that on a small canvas, but with large import, I have ventured to sketch the one supreme educational problem of the immediate future. Believing it also to be a practical problem, to be approached in stages of progress—stages always in their essence determined by principle, though measurably shaped by expediency—I have reserved for the last some considerations of possible reform.

And first, defensively, let us not dwell unduly upon the incompetence, the conservatism, the inadequacy in practical affairs, of faculty men. It is hardly consistent to ascribe these qualities indiscriminately to the men of the academy, and then for the most part to find in this group the very persons who develop with experience into efficient administrators. As a class, professors are able to take a helpful share in the shaping and carrying out of measures conducive to educational welfare. Their practical insufficiency is a result, not an excuse, for the present system. This has not been overlooked by other writers.

> We appear at present to be between the Scylla of presidential autocracy and the Charybdis of faculty and trustee incompetence. The more incompetent the faculties become, the greater is the need of executive autocracy of the president, and the greater the autocracy of the president, the more incompetent do the faculties become (Cattell).

And from another:

> But was there ever a more vicious circle of argument than that which defends the persistence in a system productive of such unfortunate results by urging that the personnel of the profession has now been brought so low that the restoration of its inherent rights would entail disastrous consequences? (*Dial.*)

Once given their due professional responsibility, academic men will develop—as is abundantly evidenced in the conduct of laboratories and departmental affairs—the qualities requisite for the service. The ghetto into which externalism has driven them is admittedly the least suitable habitat for the nurture of the qualities which they should exhibit; but is this an argument for the retention of the barrier?

Let us hopefully, though not blindly, look forward to as adequate a management—doubtless a simpler and saner management, with less emphasis upon managerial factors—under internal as under external control. And if there are losses, as there will be, let it be borne in mind that there will be gains to offset these, endlessly more important, in the near future as in the long run, indefinitely more worthy.

If we ask next, constructively, how shall this be brought about, let me confess that I am somewhat fearful of a policy of gradual veering, of successive short tacks to each gust of shifting sentiment. By all means evolution and not revolution; but also by all means steer and do not drift. If we are on the wrong track, let us manfully confess it and set the compass to a different course. There is already in the air a growing sentiment against autocracy, a decidedly increased willingness, even an anxiety, on the part of presidents to seek counsel and to prevent the ruptures invited by the official organization—all this parallel with an increasing development of organization upon principles antagonistic to real professional independence. It is obvious to all that so impossible a situation as that now made publicly available by the commendable willingness of Dean Kent to set forth the facts of the case is not likely to recur; and the next president of Syracuse University will be both a wiser and a happier man because of the public indignation aroused by this extreme example of presidential autocracy. Presidents are likely more and more to be benevolent, even condescending; and their efficiency is admitted. But as Professor Cattell says: "The benevolent and efficient despot is the worst kind; the cruel and incompetent despot soon disappears." The increasing graciousness and reasonableness of the administrative attitude, while it mitigates the situation for the present dwellers in the grove, must not be permitted to set aside the real need for reform. Such reform, I have urged, comes alike from the guiding dominance of principle, and the facilitation of a suitable organization. The most practical outlook is towards university presidents of different views of administration, of independent insight, not overawed by convention or popular prejudice, of a democratic temperament. I hold, as do others, that one of the first requisites is that faculties shall elect their own presidents; and the legal relations being what they are, I look forward (perhaps telescopically) to the day when no worthy man will be willing to preside over a faculty unless invited by them to this place of academic leadership. More than this, I believe it essential that the faculty invest the president with such authority and only with such as they regard as desirable for academic welfare. Professor Stratton, quite independently, has expressed the same conviction:

> Still more important and beneficial for our present needs would it be to have the professors rather than the trustees elect the university president and determine the powers which he should yield. The office of president would thus remain, but he who occupied it would be the representative directly of the faculty, and he could be efficient only so long as he retained their confidence.

Equally important with this reform is another: the authoritative voice of the faculty in the determination of what measures shall be decided with the cooperation of the board, which by the board alone, and which by the faculty alone, and with this an essential representation of the faculty at the meetings of the board. An effective provision seems to be that of a joint council of trustees and faculty, or an advisory council to the president as at Stanford University. With the establishment of these reforms or their equivalent, the rest may confidently be left to the wisdom that universities have already shown themselves to command, and to the cooperative spirit which these changes inevitably incite.

Should it be said that by my own argument, administrative methods are secondary and that the great struggle needed to effect these changes will not be justified, I reply first with a decided assent, and second with a vital reservation. Naturally administrative measures are of minor importance if academic ends are secured; but it is because the current methods are directly subversive of such ends, and because, most of all, they imperil the academic career, and wantonly deprive it of its due standing, that the change of such methods becomes the major concern of the present educational situation. "The constitution of our universities is an appearance of their indwelling mind, and therefore it is of moment for their future" (Stratton).

The outward semblance and public garb of the university, no more than personal beauty, is skin deep. Or if, indeed, we consider it such, the retort is at hand, that at all events ugliness goes right down to the bone. The unfortunate and distorted features of the academic system are not superficial; and the remedy likewise must be radical. While I make my plea for administrative reform dominantly because I am so deeply convinced that the rehabilitation of the academic career is possible only upon that condition, I yet emphasize that the welfare not alone of the profession will be secured by the change of front which is the consummation alike to be wished for and to be worked for, but equally that the good of the student community and of all that makes for the strength of the university will be similarly advanced. Measures will then be the issue of an inner harmony, of a slow maturing conviction, of sensibilities and perceptions fostered by the experience of the academic life. As has been well said, a university—like much else in this world and very different from the advertising fusilade of commercial blank cartridges—a university works best when its work is quiet and deep; and all its forms and organization should express and strengthen this idea.

Ordinarily, amid the routine of pressing duties, in the leisure between obligations, under the ever-present sense of accountability, the dweller in the modern grove checks his enthusiasms, and withstands the temptation to unfold the future. But in surroundings, such as these and under the incentive of occasion and with a sympathetic body of hearers, he is emboldened to disregard the overcast horizon and contemplate distantly, yet hopefully, the things that are to be.

THE SPECIALIST BLIGHT ON AMERICAN EDUCATION

By JAMES P. MUNROE

BOSTON, MASS.

SPECIALISM is the order of the day. From the professor of Greek down to the "professor" who shines one's shoes, that man is in demand who is disposed to concentrate all his energies upon the learning or the doing of one thing. Even our households have become infected, for therein is now to be found the very apotheosis of specialization. Even so late as the beginning of the last quarter of the nineteenth century, one maid would do substantially all the work of the house; whereas, to-day, the lady who condescends to burn one's beefsteak and to parboil one's potatoes will not enter the laundry or the dining-room, while the other maid (or maids) would join the family in general starvation before so far forgetting her "place" as to cook a single meal.

But what can be expected of the rank and file of the modern world when the leaders of American life, men in the professions and in those higher institutions which prepare for the professions, have seemingly gone mad upon the question of specialization? Like the gypsy-moth, the specialist was imported from Europe, either directly or through young men who went there for medical, linguistic or other higher studies; and many a green tree of scholarship, many a fair, broad field of general culture has been converted by this importation into a naked waste of narrow pedantry.

Of course, the time has long gone by when any man, no matter how brilliant, can, in Bacon's words, "take all learning for his province." But that does not justify the running to an opposite extreme, does not excuse the digging of a hole in the side of a small mound of erudition, getting into the farthest end of it, and maintaining that the tiny patch of sky framed by the mouth of the hole is all of the universe worth while. It is probably necessary that some man should spend his whole life grubbing at a certain obstinate Greek root; but why call him learned, when he is simply industrious? Why reward him with titles and emoluments, and give no scholastic encouragement to the far less erudite man who is nevertheless sending intellectual and moral roots over a wide area of human thought and life?

The curse of American scholarship and of American education is the Ph.D. For in exalting this decoration of the specialist, we are repeating the error of the Schoolmen, who confounded erudition, which dries up the soul, with real wisdom, which expands man into almost the very image of the All-Wise. Yet this hall-mark of erudition is to-day practically essential as a key to a faculty position; and it is so, not because there seems any valid educational reason for it, but largely because it is required in Germany and looks well in the prospectus. As a result, hundreds of young fellows are starving themselves and impoverishing their parents in order to secure this decoration. To get it they are pursuing so-called special investigations, by counting the number of adverbial clauses in Shakespeare, or by sending out questionnaires regarding the proportion of children who twiddle their thumbs. Having scraped together this fatuous information, they are spending much time and money in having it printed, in order that another doctorial dissertation may be added to the dustiest shelves of the college library. And these most precious years of a man's life, these years in which the youth ought to be learning how to broaden his mind and capacities, how to deal with men, how to handle his faculties, his tongue and himself—these the poor fellow is selling for this mess of pottage with which to feed the trustees of some lesser or greater university.

Having been admitted to the teaching staff of the university, the fledgling Ph.D., if he is to hold his place, must produce something, and that quickly. But since his days, as a subordinate teacher, are mainly taken up in such intellect-killing work as correcting thousands of themes or counting the apparatus in the laboratory, how is he to get that breadth, experience and wisdom which alone can make what he is expected to produce of any value to the world? Half-starved physically and wholly starved intellectually and socially, his only alternative is to specialize still more, digging, like a woodpecker, into some wormhole of erudition in the hope of extracting from it a maggot large enough to placate the learned university public accustomed thus to be fed by young doctors of philosophy. This digging is politely called research; but it is the sorriest counterfeit of the genuine thing, being but perfunctory and profitless grubbing. True research must be founded upon wide scholarship, upon profound knowledge of men, and upon extensive acquaintance with the world of letters and of things. To compel such callow men as these to specialize is to condemn them to intellectual suicide and, in so doing, to kill true scholarship.

In this hard-hearted world it would not very much matter that these poor aspirants should waste their intellectual powers in this way, did it affect only them and their long-suffering wives. But it is these men, as a rule, who become professors and heads of departments, it is they who determine the atmosphere and the trend of the colleges, it is this type of specialist who is setting the standards of learning and of scholarship for America. As a result we have our college populations sharply divided into grinds and drones; we have our professions filled with men who can do much within the little cell of their speciality, but who are wholly ineffectual in the great world of human interests; we have a rich and powerful civilization that is breeding pitifully few great leaders of human thought.

There are only two kinds of simon-pure specialists allowable: the genius who has such a volume of treasure to bestow that every minute of his life should be devoted to dispensing it; and the man who is given the power of concentrated digging and who is vouchsafed no other ability. The latter will grub out the absolutely essential minutiæ without which learning can not advance. The former will call down from heaven those divine fires which are to keep civilization aflame. The number of these specialists, however, is, in comparison with the university population, infinitesimal; and the great mass of educated men need, not concentration, but expansion, an intellectual highway, not a groove. Of course, every man who hopes to amount to anything must specialize in some degree. He must have a vocation and must strive towards the highest achievement in that specialty. But he must have, in addition, avocations to broaden and harmonize and sweeten him; and even his vocation must be founded upon such a knowledge of men and of life that—at least before his fortieth year—he could take up any other vocation and succeed in that.

We specialize our grammar-school children in bank discount and leave them to life-long ignorance of what mathematics really means. We specialize our high-school youth in battles and sieges and permit them to remain ignorant of the great historic development, through industry and commerce, of mankind. We specialize our college youth in haphazard electives, each taught by a specialist and most of them unrelated to all the others, and turn that youth out of college a veritable ignoramus in regard to himself and to those other selves with whom his whole subsequent life will be concerned. We send out from our schools of applied science many a man competent to put up a bridge, but not competent to put up a good front among his equals, wise in the handling of formulæ, but ignorant in the handling of men, full of little knacks and methods of calculation, but empty of that tact and that intellectual skill which are absolutely essential to professional success.

The college teaching of literature, for example, is being dried and mummified by specialists until the study of human thought has become a sort of subterranean, philological treadmill, with never a glimpse into the wide, high, lasting things to which literature should lead. College philosophy is, as a rule, but a comparative anatomy of dead and gone systems, never, as it should be, an inspiration to wisdom, leading to the love of and search for truth. And how seldom is the teaching of science a real search into fundamental principles and an exposition of all-embracing truths! "Facts," said Mr. Thomas Gradgrind, "facts alone are wanted in life"; and facts—the more minute the better—are the goal and joy of the specialist. But man is not an examinable fact; he is a veritable kaleidoscope of elusive impulses, impressions, ideals, fictions; and it is with man that the whole life of the educated man is to be lived.

In our schools and colleges (and especially in our professional schools), we need to get back to the humanities—not to the humanities of Greece and Rome as expounded in Oxford and diluted in America; but to the humanities of the twentieth century. For the study of the real humanities implies a working-knowledge of humankind, of men. We have been so overwhelmed with facts and discoveries and theories and inventions and names and classifications, that we are forgetting that the main fact in life is you and I. We have been so busy stuffing our children and our students with these facts that these classifications, that we are forgetting that the main things which they, as men, must know are men. Therefore give a boy, give a student all the facts and all the practise that he can get in school and college, provided you do not fail to give him, at the same time, a broad outlook upon history, upon literature, upon human experience and human life. Whether he is to start in a store, in an office or as a "drummer"; whether he is to be a minister, a lawyer, an engineer or a doctor, his success in life depends enormously upon his ability to get on with and to handle men. He can not have that success unless he is broad, catholic, tolerant, tactful and philosophical; and he can not be those things unless he has been trained, not as a specialist, but as a man. By success is not meant, of course, mere financial and professional success—though in nine cases out of ten those are most likely to be achieved by the broadest man—but that highest success which comes through the widest social usefulness, through the consciousness that one has got out of life that which has made the pains of living really worth while.

It may be an exaggeration to say that American scholarship is in a deplorable condition; but every American must acknowledge that we do not produce our due proportion of great men. There are, of course, many excuses which may properly be offered; but one of the fundamental reasons is that we permit our promising youth to specialize too soon. Consequently their scholarship, to paraphrase Bacon, is that of boys, who can talk but who can not generate. To produce men with the loins from which will spring great contributions to human thought and action we must gradually make over our whole system of elementary education so that youth, instead of being put through vast machines for imparting facts, shall be put into small classes under intellectually strong women, and especially under intellectually and morally strong men, who shall really develop that boy's mind and character. We must then persuade the college authorities not to turn callow undergraduates into a jungle of courses taught by specialists, but to lay out for those boys really developing and strengthening coherent work which shall make them acquainted, as far as they can learn at that time of life, with men, society, philosophy and genuine wisdom. As to professional training, the physicians are getting most nearly at the heart of the problem by means of their clinics, their hospital and "externe" training, through which the embryo physician studies not simply medicine, but human nature and human life.

Supposing a youth to be really educated in school and college and to be genuinely trained in his professional school, he ought not to specialize until he shall have had a number of years of wide experience in his work, until, if possible, he shall have traveled, until he shall have taken a thorough, graduate course in the university of the world. Then he will have breadth and wisdom and true learning; then he will know real scholarship from false; then he will be humble, reverent and eager to know the truth; and only when a man arrives at this mental and spiritual condition is he fit to be a specialist. Even then, as has already been said, no man except a genius or a "grubber" is justified in being an out-and-out specialist. All others must have at least one avocation with which to temper and to put in proper perspective their chosen specialties.

SOMETHING NEW IN "FREEWILL"

BY PROFESSOR GEORGE STUART FULLERTON
COLUMBIA UNIVERSITY

IT has been maintained that all men are born free and equal. Shall we accept this very broad statement as it stands? or shall we repudiate it as a palpable untruth, an absurd exaggeration of the actual state of things?

There can be no doubt that from certain points of view, abundant objection can be brought against it. Is a baby free to go where it pleases? Or a child of five to discipline its parents, and control the key to the pantry? Is a boy free to vote? Or to raise money on a note? Is a lady free to play poker on the curb-stone? Or a clergyman to supplement his insufficient salary by serving during the week as end-man in the performances of a minstrel troupe? Is a banker free to close his establishment every time that there is a football game between Yale and Harvard? Freedom! Where is freedom? We are all of us hedged about by restrictions of a thousand sorts, and we are not hedged about by the same restrictions. What I am free to do, another is not free to do; and what he may do is forbidden to a third. Where is this freedom attributed to all men? Some men incarcerated in cells by legal process appear to be conscious that they are not free. The larger number not thus provided for talk much about their freedom, especially at certain seasons of the year, but when we subject them to critical inspection, we find that they only seem to be free to do certain things determined by such circumstances as age, character, sex, station in life, official position, and a multitude of others. Each human being is certainly not free to do what every other is free to do. What a droll world it would be if he were!

And as for equality—talk not of it! Would any man in his senses maintain that a baby not yet "shortened" is equal in size, weight and intelligence to a senator or a college president? Is a boy equal in foresight and power of self-restraint to a man of forty? Are all school-children equal in mathematical ability or in artistic skill? Are all women equally beautiful and equally talkative? The man who really believed in the equality of human beings would make the candidates for the presidency of the United States pull straws, or would toss up a copper to decide whom he should marry. Even if we confine ourselves to men as "born," as still in the cradle, we can not regard them as equal—the hydrocephalous infant is not to be confounded with the normal child, nor the Bushman's baby with the offspring of the Anglo-Saxon.

But, it may be objected with impatience, why all this insistence upon what is so perfectly evident? Why whisper around the secret of all the world—the very first thing that our common experience of mankind brings to our notice? We do not have to wait for science to tell us that men are not so outrageously free and so ridiculously equal. Science corroborates what common experience reveals, of course; but does not every one know of himself that when we warm up over the subject of the rights of man, and grow pardonably oratorical, we never intend to be understood with a literal exactness?

Yes, everybody knows, under normal circumstances, that men are not alike, and that it would be the very height of all that is unreasonable to expect all to act in the same way. No man of sense goes to the thistle for figs, or to the penitentiary for saints. And as human beings differ, and may reasonably be expected to find the attainment of the halo difficult in varying degrees, and the descent to Avernus easy, easier or easiest, according to their proclivities and to the help furnished them by their environment, everybody knows that there is no sense in treating all men alike, if our object is, as it ought to be, the betterment of society. One man does not need special inducements to be good; one has to have a cake dangled before him; one would be cut to the quick if the cake were merely hinted at. One man needs a gentle admonition, as his feet begin to move on the above-mentioned slope; a second must have a pretty sharp jerk, if he is to be stopped in his downward career; a third whizes by with such an impetus that to lay hands suddenly upon him is to endanger his comfort and happiness. Shall we treat them all alike, and call it even-handed justice?

Everybody, I say, knows, under normal circumstances, that it is folly to expect men to act alike, when they are not alike; to look to see them influenced in the same way by the same object of desire or aversion; to hope to make them better by offering the same rewards or by holding up the same threats of punishment. The same heavy dumpling that will lure the hungry schoolboy to the paths of virtue, will drive the aged dyspeptic to the vice of imprecation.

But men only know this, be it marked, under normal circumstances. We must recognize the fact that men—not stupid men, or ignorant men, but men of the highest intelligence and of much learning—are capable of putting all this resolutely behind them, and of knowing nothing save that all men are free and equal, when they fall into the clutches of a certain strange metaphysical theory.

It is wonderful what abstract metaphysical reasonings will do. They have smothered the voice of seemingly indubitable fact, and have led men to deny the existence of the external world. They have induced some to maintain that every man has his own truth, which is true for him; and others to advance the doctrine that no truth is attainable by man. They have caused one philosopher to talk as though he had created the world; and another to declare that there is no evidence of the existence of minds in one's neighbors. Not the least remarkable feat is the production of the persuasion—a persuasion very tenaciously held to by some—that there is something cheering and even pious in the doctrine that men's actions are, to some degree, at least, quite unaccountable, and can not be expected to be congruous with the character and environment of the person in connection with whom they mysteriously make their inexplicable appearance.

This does not at all mean that we are in a measure ignorant of what individuals and classes of men will do under given circumstances. No man denies such ignorance on our part, and all men strive to lessen it. It means that no conceivable increase in our knowledge could be expected to help us—that we are not concerned with the question of knowledge or ignorance at all. It means that certain actions have nothing to do with what has preceded them; nothing with the character of the supposed agent, but who is really not the agent; nothing with his surroundings with the influences which have been brought to bear upon him. Such actions just appear; nobody causes them, nobody can prevent them. There is no reason why they should happen in connection with one man rather than with another, or at one time rather than at another. There is nothing in any one to call them into being or to inhibit them. The baby, the grown man, the hardened criminal, the philanthropist, the dullard, the man of genius, the devoted mother, the cold-hearted coquette—all these may suffer such actions, and there is no more reason for expecting one of these to serve as the stage for their appearance than there is for expecting another to serve as such. The play has nothing to do with the stage; it may break out anywhere!

O tempora! O mores! are there those who harbor such thoughts about their fellow-men? Indeed there are; this is the doctrine of the "freewillist," stripped of its domino and set out without disguise. I am convinced that it would not even get a hearing, were it not that we often confuse it with the very different doctrine that men are under certain circumstances free, and that we come to regard it as the opposite of that very unscientific doctrine fatalism.

Of freedom, "freedom," and fatalism I have already written at some length in The Popular Science Monthly,[1] and I shall not treat of them in detail here. But we have recently been offered some such curious "freewill" reasonings by Professor James, in that much-discussed little work "Pragmatism," that I can not but think that a brief

[1] December, 1900, and October, 1901.

examination of them will be found interesting. In any case it ought to be useful to some; for when an author writes with passion and vehemence there are those who are in danger of being swept away with the tide of his eloquence, and of forgetting that they must not close their eyes to the world of palpable and admitted fact that lies about them.

Professor James makes lively objection to the emphasis which some of us have laid upon the fact that there seems no sense in making a man responsible for what he did not do and could not prevent; in other words, in rewarding or in punishing him for "freewill" actions, which, by hypothesis, do not spring from anything that is in him, but just "happen" to the poor man. "Freewillists" have sometimes maintained that only such actions can be regarded as creditable or the reverse. It does not seem out of place for the man who sympathizes with common sense and with science to point out that to reward a man for what he did not do and can not do again, or to punish him for what he did not do and can not be prevented from having happen to him again, is highly absurd.

This answer of common sense to the position taken by the "freewillist," may, it is admitted, be good *ad hominem*, but it is declared to be otherwise pitiful. Every man, woman and child, with a sense for realities, ought, we are informed, to be ashamed to plead such principles as either dignity or imputability.

> If a man does good acts we shall praise him, if he does bad acts we shall punish him—anyhow, and quite apart from theories as to whether the acts result from what was previously in him or are novelties in a strict sense. To make our human ethics revolve about the question of "merit" is a piteous unreality—God alone can know our merits, if we have any.[2]

Now the common-sense determinist, that is, the man who believes in human freedom in the ordinary signification of the word—who thinks that the good man will freely choose the good, the bad man the evil, the wise man the prudent course of action, the rash and imprudent the gaming table—the common-sense determinist, I say, can have no quarrel with the position, taken by Professor James, that utility must be consulted in carrying on the social business of punishment and praise. What more natural than that the man who believes human actions to be explicable, even if not always explained, and who has confidence in the efficacy of persuasion, reward and punishment, should consult the principle of utility. He wishes to attain certain philanthropic ends; he believes that they can be attained by the employment of the appropriate means; and he turns to the means.

But the common-sense determinist, like every one else who takes an interest in ethics, must find rather paralyzing the idea that we should eliminate from ethics the notion of "merit," and should praise

[2] "Pragmatism," p. 118.

and punish without taking into consideration what is in the person with whom we are dealing. That such a doctrine should be brought forward at all, can only be explained, I think, on the ground that the "freewillist," having been brought up to think that "freewill" actions are, above all others, the actions of which ethics must take account, and now being brought to a consciousness of the absurdity of talking about the merit or demerit of "free" actions, feels driven to the extreme statement that we must banish the notions of merit and demerit from ethics altogether.

To be sure, it is hinted that we are forced to drop all consideration of merit, not because we are assured that there is no such thing, but rather because we must remain in doubt as to who may justly lay claim to it, if any may—"God alone can know our merits, if we have any." So far as our dealings with our fellowmen go, however, it is as though there were no such thing; and with merit goes demerit; and, of course, their synonyms good and ill desert go, too. We must not look upon men as deserving or undeserving, for "God alone can know" in such matters as these.

Now I beg the reader to open his eyes upon his own life and that of his companions, and to ask himself whether he would ever dream of living through a day under the guidance of such ethical principles as are here suggested. Remember that the principles are these: he who does good acts is to be praised; he who does bad acts is to be punished; no consideration is to be had to what is in the agent, he is to be praised or punished "anyhow"; no act is to be looked upon as meritorious or the reverse, as creditable or discreditable.

Think of the frightful insults which one living a day under these principles would, by his indiscriminate praise, heap upon the unoffending heads of the good—the uncalled-for compliments paid to gentle old ladies on their keeping out of street brawls; the congratulations lavished upon the president of the temperance society in view of the fact that he passed a dozen saloons without going in; the warm grasp of the hand given to the college professor for his regular and studious habits. Think of the cruelty which would result from treating all offenders alike—the mature and the immature, the case-hardened and the man who has succumbed to sudden temptation. Think of the distortion of the moral judgment which must result from embracing the opinion that nothing is creditable or discreditable to anybody. That freshmen should skip like lambs does not seem unnatural or unbecoming; but that the venerable men who are set over them should disport themselves as rams must be regarded as discreditable, I submit, by any unbiased mind.

Such a day as the one referred to above would be a day in a thousand, and its description well worthy of the pen of a ready writer.

Lack of space forbids my attempting such a description, and in any case, I lack the imagination which would do justice to it. But, to show how impossible it is to eliminate from ethics a consideration of what is in the agents whose acts we are judging, and to eliminate the notions of merit and demerit, I shall dwell upon a single illustration.

Let us suppose that we are informed that each of two human beings has, on a certain day, told a fib, appropriated something which did not belong to him, and, in an outburst of temper slapped a companion. Let us suppose, further, that we are informed that, during the whole week following that unlucky day, neither of the persons in question has done anything of the sort, but has been truthful, honest and peaceable.

On a given day, both have done "bad acts"; shall we punish both "anyhow," or, at least, give expression to our disapproval? and shall our punishment or our disapproval be equally energetic in either case? For a week both have done "good acts"; shall we praise each "anyhow," and in each case with equal warmth?

One of the delinquents is Tommy, aged four; the other is a bishop supposed to be of sound and disposing mind. May we affirm that that unhappy day has not been more discreditable to the bishop than to Tommy? And does it seem sensible to say that the week following has not been more creditable to Tommy than to the bishop? If we talk in this way about the two, we shall find that in the home, in the school, on the street, and even among the philosophers, men will laugh at us; and we can not check their laughter with the pious ejaculation that "God alone can know" whether small boys and bishops have any merits at all, or can do anything creditable or discreditable. It is only the "freewillist" who will not laugh. Metaphysical theory seems to have cast a blight upon his sense of humor.

So much for the elimination from ethics of merit and demerit. The "freewillist," who declines to consider these notions at all, has, as we have seen, fallen into error. But he has, at least, been saved from the error of arguing, as "freewillists" have done in the past, that there must be such things as "freewill" actions, if we are to accord credit or discredit to any one. The argument is very swampy ground upon which to base such an imposing structure as the "freewill" doctrine. This Professor James admits; but, as the "freewill" doctrine must be built up at all hazards, and a lot of some sort *must* be found somewhere, Professor James offers us a bit of "pragmatic" property of his own, a few square yards of "real ground," which he thinks will sustain the weight of the edifice.[3]

Persons in whom knowledge of the world's past has bred pessimism may, we are told, naturally welcome "freewill" as a *melioristic* doc-

[3] "Pragmatism," pp. 118–121.

trine. It holds up improvement as at least possible. "Freewill" is thus a general cosmological theory of *promise*.

It is very important to understand just what this means. It means that we may assume, as a relief from despondency, that things may happen in the future which have absolutely no ground in what has been or what is. We have, by hypothesis, no means of knowing anything whatever about these things to which we look forward. We can not frame a reasonable expectation of any kind—we only know that we may expect the unexpected.

Let us imagine Schopenhauer, the pessimist, and Candide, the merry optimist, banished together to a world of this lawless description, and condemned to pass a month in the same *pension*. The beds are hard, the coffee is weak, the dinner is not wholly satisfactory, and the company is mixed.

"Candide," says Arthur, after a week spent in mortifying the flesh, "how does this strike you?"

"I shall not answer you in the spirit of the exaggerated optimism which I once tried to cultivate," responds the sobered philosopher, "for the condition of things is, indeed, somewhat trying; but I know your weakness, and I feel it my duty to point out to you that, if we may not be optimists here, we may at least be *meliorists*. In such a world as this, no one can know what is going to happen next. In this general uncertainty there lies concealed a *promise*. Cheer up!"

"Cheer up?" thunders the German, "Candide, you are incorrigible. As you have abandoned your optimism, I should be ungenerous not to modify my pessimism; but beyond *pejorism* I can not, as a rational being, consent to go. You admit that things are bad; you admit that, for all we can know to the contrary, they may at any time be worse. That is enough for me—God alone can know how miserable the next week may find us."

"But think of the *promise*," insists the man of hopeful temper, "is there nothing in that?"

"The promise? The promise of what?" is the scornful reply. "Who can take comfort in a promise so long as it is uncertain whether it is a promise to pay or a promise to extort payment? Your *meliorism* and my *pejorism* are the same thing, or two aspects of the same thing—the thing may best be described as discontent with the present and complete uncertainty touching the future."

Candide relapses into silence; he can not conscientiously load the dice of "freewill" and make them work together for good. He can not assure his companion that things are going to be better, when it is purely problematic whether there is going to be any change at all, and whether, if there be a change, it will be a change for the better or for the worse. He may not exercise a confidence in the Cosmos, or in

God, or in anything, for "freewill" changes would not be "freewill" changes, if they had their ground in anything that is or has been. He sees clearly that the watchman which he has set on the wall to tell him of the night has no other task than to come down from time to time and inform him that it is conceivable that something may happen, but God alone can know what that something may be. Why keep a man out in the cold just for this? Let us rather bring him down and put him beside the fire.

And Schopenhauer is, I think, more nearly right than he usually was when he was in the body and on this planet, which science will not recognize to be a "freewill" planet. Surely it is not reasonable to take comfort in mere uncertainties as such—in promises which promise nothing. A reasonable hope, even a faintly reasonable hope, must have "some outlines and shadows" of a foundation, as Maritornes, though a sinner, had "some outlines and shadows of a Christian."

May we, then, harbor no hopes unless they are reasonable hopes? May we never hope against hope? May we never lighten dark hours by insisting that sometime the dawn must come?

I should be the last to insist that we must be as coldly rational as this. One of our problems is the problem of getting through life and of being happy and cheerful if we can. One can, as a help to this, embrace a faith, clearly recognizing that it is a faith and not a scientifically established doctrine. One can look on the bright side of things, knowing well enough that the bright side is not the only side, and yet preventing one's mind from dwelling upon what lies in the shadow.

I can not see that this would, in itself, do harm. We are concerned with a *rule of life,* and one may adopt such a rule without necessarily clouding one's intellect or repudiating the open mind. But when one undertakes to bolster up a faith adopted in this way, by the invention of arbitrary metaphysical hypotheses, which introduce confusion into the science of ethics, and which make of this orderly world in which we live a realm of anarchy, a scene of disorder, in which prudence and forethought and knowledge lose their significance—when one does this, one goes, I maintain, beyond what is permissible, and one does harm.

It has been well said that one must not judge of a man's intellect from the religious doctrines which he elects to embrace. It is the man who chooses these things; not the mere intellect. The man may be acute, and he may be learned; and he may, nevertheless, hold opinions which seem to us narrow and unenlightened. Too many things go to the determination of the religious belief of a given individual, to enable us to judge him in summary fashion.

And is it not somewhat the same in philosophy? I do not say that it ought to be just the same in philosophy; but, as a matter of fact, is it not much the same? He who supposes that the philosophers are free from the passions of other men does not know the history of human thought.

As to the "freewill" controversy, it has been penetrated through and through with passion and with prejudice. The real impulse which makes men "freewillists" showed itself more than two thousand years ago, when a man who cared little about *meliorism* and cared a great deal about doing as he pleased without external interference, invented the "freewill" doctrine, under the mistaken notion that it released him from the decrees of fate. Some men wish to be freed from fate from higher motives, and some from lower; but freed from it we all of us wish to be. And just so long as men confuse "freewillism" with the doctrine that men may be free, will they determine at all hazards to be "freewillists."

In their desperation, men of real ability will urge arguments that are not arguments, will propose remedies that are worse than any disease likely to overtake us in the course of nature. They *must* hold on to their leaky doctrine; is not anything preferable to a surrender to the decrees of fate? But they fight a losing battle, and the exercise must be a depressing one. Is it not better to go to the common-sense determinist or to the man of science, and learn that there is no such thing as fate, and that men may be free even in an orderly world?

THE LAWS OF SOCIAL ATTRACTION

By Professor SIMON N. PATTEN
UNIVERSITY OF PENNSYLVANIA

SCIENCE is a powerful transformer of human thought and yet it is remarkable how little direct influence it has on the affairs of life. We live from day to day under the guidance of the same feelings and motives that our ancestors had long before the sway of science was felt. A new discovery attracts our attention and evokes anticipation of great changes, only to drop out of view when the novelty is worn off. Much of this lack of interest is due to the fact that the adjustments that scientific laws demand were long since made in an unconscious way so that we already do what science prescribes. A cat that, falling, lands on its feet does all that a full knowledge of gravitation demands. Law thus has a reflective use in explaining what has happened, but seldom is a force in shaping action.

There is, however, one field to which science is being applied where this conclusion does not hold. Marriage is a subject of deep personal interest and it is also one of the few fields where real choice is increasing. From generation to generation the number of those grow who settle their marriage relations for themselves. Likes and dislikes play an ever-increasing rôle, while outside pressure—be it economic, social or moral—ceases to dominate choices to the degree it did. We are forced into subordination to environing conditions to an ever-increasing degree, but we get even, so to speak, by asserting our wills more freely in the choice of mates. The economic determination of daily life is thwarted by the impulses that determine love affairs. The one free epoch of a lifetime is often the days of courtship. Can laws be formulated that cover this epoch or is the mating of men and women a matter of chance?

A notable book has recently appeared which does much to put this problem on the new basis. In his "Sex and Character" Weininger assumes that the two sexes differ so fundamentally that every organ and even every cell reflects the peculiarities of the male and female plasms from which they arise, each representing the normal results that follow from the original differences in the sex cell. He holds, however, that there are few, if any, pure males or females, but that most men inherit some female characters while in women male characters are equally common. The ordinary woman is dominantly female, not purely so. The ordinary man in turn is dominantly male and yet some of his characters are female. If every man was a pure man and every woman a pure woman any man would be attracted by and suitable for any woman. There would be no basis for individual preference, because the qualities and impulses demanded would be found in any individual of the opposite sex. There would thus be no law of individual attraction. But with the intermediate forms—those partly male and partly female—each person likes in his mate the qualities he has not. Where he is male he demands female qualities in his mate, and where he is female he is attracted by a woman who in these respects has male qualities. A womanly man prefers a masculine woman and she in turn would be attracted by him because each finds qualities in the other that they do not possess. If the positive sign (+) be made to represent masculine characters and the negative (—) the womanly qualities then each fitting couple would have in the one a plus quality where the other had a minus quantity. Weininger states his law as follows: "For any true sexual union it is necessary that there come together a complete male (M.) and a complete female (F.) even although in different cases the M. and F. are distributed in different proportions." The truly male part of a man and the truly male part of his affinity will thus make an ideal man, while the truly female parts of the two make an ideal woman. Each wife should possess that amount of maleness that her husband lacks and he should be female to the degree and at those points where she is male. Where two people are male and female in the same qualities there will be sexual aversion with no inclination to mate.

The interest in this doctrine is increased by the application its author makes of it to the problem of woman's emancipation. The pure woman, he contends, does not want independence and equality with men. She is dominantly sexual and cares little for what is really foreign to her nature as a woman. It is the sexually intermediate forms that desire emancipation. To the degree that a woman has inherited qualities that are male she will have a deep-seated craving to acquire man's character and to have his freedom and ability. All successful women show the dominance of male characters. George Eliot, he tells us, had a broad massive forehead: her movements, like her expression, were quick and decided and lacked all womanly grace. It is this male element in women that longs for equality. The womanly woman never pays any special attention to art or to science, or if she does it is only as a means of attracting a person of the opposite sex. Women really interested in intellectual matters are sexually intermediate forms. The whole woman's movement is thus unnatural and artificial. It creates an undue amount of excitement that ends in hysteria. Any attempt to emancipate all women is sure to defeat itself by the artificiality and misery it creates.

This book is a contribution to the problems discussed, and yet I feel that it has been put in a wrong setting and is therefore capable of a different interpretation than that which its author gives. The difficulty in applying biological principles to sociological problems is so great that any slight error leads to radically false results. Social thinkers must use biology, but care must be taken not to isolate some one principle from related doctrines which if properly presented would vitiate the reasoning drawn from a narrow field. The qualities of mothers are inherited by sons and those of fathers by their daughters, so that if there are any special sex characters they would soon appear in persons of the opposite sex. We are thus intermediate forms with characters coming both from our fathers and mothers. But it does not follow from this that sexual affinity is due to this mixture: for this would assume that we have a special liking for qualities absent in ourselves. On the contrary, we like those like ourselves and have an aversion to those who present differences no matter how slight.

The doctrine of sexual affinity should be so restricted that it will conform to sociological and psychological laws as well as to those of biology. This can be done by keeping in mind a distinction that Weininger has overlooked. Were all characters natural and none acquired, we might assume that they were male or female. But acquired characters can not thus be divided. They are carried along by a social heredity which impresses its effects on both sexes alike. Weininger assumes, however, that all characters are due to differences in germ cells and that every one in his development reveals the tendencies active in them. These tendencies, however, are thwarted by adverse conditions, so that each individual at maturity is either far short of his full development or has been pressed in other directions than forces of the original germ cell would dictate. Differences between men are thus due not merely to variations in germ cells, but to defects which arise out of bad conditions. Persons with the same germ cells may differ more radically at maturity than they differ from those whose germ cells represent some variation in the species. Food, housing, light, air and disease are of prime importance in creating the peculiarities which appear at maturity. The modifications which culminate in some variations of the racial type are in any age too slight to be of importance in accounting for the marked differences which appear in mature men and women. These differences are defects due to bad conditions, not peculiarities of germ cells. They represent retardations in development, not modification of the racial type. We are all short some characters which our heredity would reveal if conditions favored and these shortages are of such infinite variety that scarcely two individuals are alike.

It is generally admitted that improvements in the human race can be made by crosses increasing the number of natural characters. But is sexual affinity a peculiar bond that adds to the attractiveness of other stocks and races or is it an index of defects imposed on individuals of the same stock by shortcomings of their environment? Is an affinity a person of the other sex just like ourselves in heredity, but with other defects, or is this affinity a person of other stock or race enclosed and harmonized by the influence of the same environment? The answer to these questions is to be found not in biological studies of germ cells, but in psychology and physiology. An affinity is a strong dominating form of attachment which suppresses the ordinary thought processes and puts in their place many unique emotions and illusions. We immediately recognize the abnormality of the actions of two such people and know that only the breaking of the spell will restore them to normal life. It is thus a feeling akin to hysteria and has the same general causes. Like hysteria, it is not a character, but an abnormality. It is a state of deficient emotional control—a paralysis of the higher centers that should dominate thought and activity. Irritability, passion, uncontrollable sex feelings and hysteria all represent the lack of something that is normally present, not the presence of characters absent from normal people. They are manifestations of retardations through which people fail to reach a full development. Defects represent the loss of characters due to this retardation. The higher centers fail to act with sufficient promptness and the retarded person falls under the control of strong persistent feelings that upset normal thought and control. In the parts where defects appear instead of positive characters, emotion and hysteria control instead of reason.

These persons with abnormal tendencies are aroused and dominated by the fully developed people of their own type; they have an aversion to people of other types. If a person is naturally musical, but through some defect or disease his powers are practically dormant, he will be lifted into a new realm by persons of great musical power. The capacity to enjoy music is in this defective person; it is made dormant by adverse conditions, but it can be aroused by contact with musical talent; and is forced by the new stimulus and excitement through a rapid development. There seems to be a miraculous change and with it a tremendous emotional outburst. The strong thus exert a tonic influence over the weak and retarded of their own type. The hero is not a super-man; he is the normal man; his followers are just like him in character and heredity. The defects of environment and personal development have kept them from attaining his level and give to him a dominance over their lives through the stimulus towards a better self-expression than his example and life give. The instantaneous conversion of religion does not come to the normally developed man, but he can stimulate a conversion in defective, retarded people of his own type. Strong emotions, irresistible impulses, instantaneous changes, self-subordination to heroes and mob rule, are thus marks of defective development and of abnormal growth.

Sexual attraction is strongest between two people of the same stock with different defects. Whoever has a character of normal excellence will arouse, stimulate and subordinate one of the opposite sex who has this character in some retarded or abnormal form. If two people of the same stock have different defects each will control and arouse the other where he is normal and his mate is abnormal. The feeling of affinity is greatest when half of the faculties of each is dormant, while the normal part of each complements that of the other. Weininger asserts that two affinities taken together would show the characters of a normal man and a normal woman. I contend that the sum of their characters equals that of one normal person. He thinks that the children of these affinities will be stronger and better than the average of mankind because the qualities of their parents make a normal man and a normal woman. I contend that these children will be below the average because both of the parents are defective and the children will be subject to even more retardation in development. Let us assume that in two families on intimate terms the wife of one finds that the other man is her affinity and wants a child by him and that her husband assents promising to raise the child as his own. Weinmyer would say that this love child would be above the average of the two families, stronger in intellect and body. In my opinion it would be weaker and more defective. From his position this act should be commended; from mine it should be punished.

If I am right, Weininger is also in error in regard to woman's emancipation. He starts with the thought that the characters of men and women are different and that the emancipated woman is an intermediate form having masculine qualities. In the development of his thesis, however, he shifts over to the assumption that all positive characters are masculine and that the pure woman is nothing more than sexuality. This failure to find definite characters in woman shows the falsity of the assumption that characters are the result of sex heredity. The undeveloped man is dominated as much by sexual impulses as is the retarded woman. Positive characters that raise them above their sexual appetites come to women as to men only by the process of development. The environment of women, however, is more defective than that of men and the drains on her system are more severe. Few women go far in their development before defects become so numerous as to check further progress. If they escape these set-backs they develop the same characters that appear in men who have an unobstructed development. The emancipated woman is thus not the hysterical woman out of her normal place, but the woman with a more favorable environment than her sisters have. Her gains in character due to these better conditions lift her to the plane of the normal man and give her his characters.

If sexual affinity is due to complementary defects and not to complementary characters it is but an example of the general law of social attraction. A social leader is not a man with additional powers to those possessed by his followers. He has a full development of all the possibilities of his heredity while they have many of these qualities, dormant or partially developed. The defective have the capacity to feel, but not the power to see or to express. They admire those who can do what they desire and feel should be done, but which they can not of themselves execute. Social affinity is thus the bond that unites the defective to the normal. The defective follow leaders not because they are imitative, but because they are stimulated and aroused. Imitation is a habit that increases the regularity of life. Emotion and hysteria result from defects that promote irregular spasmodic action. They become social only through the presence of normal individuals who subordinate the weak and defective to their own ideals. Retarded development, defects, lack of control, strong emotion and hysteria are the roots out of which social attraction grows, and the resulting law is quite as fundamental as is the law of imitation upon which so much of social thought rests.

The law of social affinity is a law not of human nature, but a law of deficit: for defects are due not to heredity, but to a bad environment. It is said that a hive of bees is a group of degenerate creatures in which just one individual is fully developed; the others are what they are and do what they do because they have not had enough food. A human society is not in so bad a shape, but individuals having their innate powers fully developed are so rare that men regard them as heroes or demigods. What these few become is the standard to which all might attain if environment, health, nurture and education were given them. We need better feeding more than better breeding. Were a higher type of beings demanded it could be secured only through the slow process of biological development, but if noble qualities are already a gift of heredity kept from expressing themselves through defective conditions, we have it in our power to lift the whole of humanity to its natural level. Income and nurture lie at the basis of social progress. To lose these essential conditions means a retarded development, unrestrained emotions and a lack of rationality in action. Reason controls the normal man; primitive emotions and hysteria control the abnormal.

Social attraction binds these defective creatures to their superiors and thus preserves the race from social degeneration, but it does not prevent physical degeneration. Sexual affinity is strongest between those with complementary defects, and hence a steady decline in physical vigor follows emotional marriages. The weak man or woman is absorbed in one individual and hates or at least is indifferent to mankind. Normality and great physical vigor tend in the opposite direction. They displace hysterical emotions with a vivid power of idealization by which the whole race becomes the object of thought; the gentle but vivid emotion of love that results goes out to all mankind and becomes personal only incidentally if at all. Love and hysteria are thus at opposite poles of physical vigor. Through idealization love imposes qualities on others they do not have and diminishes the antipathy of people to those of other stocks. It improves the race by favoring marriages that are real crosses, thus giving to children new and better qualities. The source of love is thus positive and within one's self while that of an affinity is negative, being aroused only by the presence of another defective individual. Love thus elevates and broadens while an absorbing affinity narrows and degrades.

In primitive times when the defective could not survive, emotional marriages like an emotional religion had certain advantages, and it is evident why they were both popular and useful, but when the dominance of humanitarian motives allows the weak to arrive at maturity, the power of affinity both in marriage and in religion becomes a potent force for evil. The broader interests of the race are subordinated to a narrow family and sectarian life. Vivid emotion and hysteria localize and isolate mankind into opposing groups. The marriage of affinities and the inbreeding of religious sectarians cut down the birth rate and reduce the vigor of each generation. There is thus a force that prevents degeneration even where the reduction of disease and humanitarian motives tend to permit the survival of the weak. Race suicide does in a generation what disease and brutality would have done in a few years. The increase in the number of normal people would lift men above the dangers of hysteria and degeneration and substitute rational methods for the primitive impulses that control our social life; social attraction based on a love for dissimilar people would then displace the power of affinity binding together people of the same stock. This higher bond can be secured only by transforming the defects due to economic deficits into the positive characters that would come of themselves if the mass of the people had income and leisure. Health, vigor, idealization and the love of those dissimilar to ourselves are steps in progress that follow the appearance of an economic surplus. The misleading impulses of hysteria and the narrowing grasp of affinity are the forces that mislead men in their marriage relations. Set them aside and eugenic marriages will be as common as now they are rare.

THE PASSING OF THE STURGEON: A CASE OF THE UNPARALLELED EXTERMINATION OF A SPECIES

By WALTER SHELDON TOWER, Ph.D.

ASSISTANT PROFESSOR OF GEOGRAPHY, UNIVERSITY OF PENNSYLVANIA

THERE is little chance for doubt that the sturgeon was originally present in great abundance both in the coastal and the inland waters of the United States, since frequent mention of the species is found in the annals of the colonial period. Probably the earliest mention of this fish is found in Burk's "History of Virginia," where it is stated that a sturgeon fishery existed in that colony in 1626.[1] For some reason, however, this early experiment did not prove successful and was abandoned. A century later Beverley's history of the same colony states that the rivers contained "multitudes of shad, rock and sturgeon," the last-named species being caught with nooses by the Indians. In fact, so abundant were the sturgeon that they often leaped into the canoes of the Indians, "as many of them do still (1722) every year into the boats of the English."[2] A letter from William Penn to the Free Society of Traders in 1683 names sturgeon first in the list of abundant fish in the waters of his province.[3] Throughout the region bordering on Delaware River and Bay the early settlers were struck at the immense number of sturgeon seen in those waters and here, as in Virginia, many and often fanciful stories are told about the fish being so numerous that they jumped into open boats. Even as late as 1850 it was not an uncommon occurrence for passengers on the ferry to see several sturgeon during a single trip between Camden and Philadelphia.

In the Great Lakes, on the Pacific coast, in Maine and southward from the Chesapeake, the records tell the same story of sturgeon in wonderful abundance. Yet, strange as it may seem, in those days of none too abundant food supply, the sturgeon apparently was not often eaten until many years after the colonies were established. It is not known just when this species was first made the object of a regular fishery. The unsuccessful Virginia experiment in 1626 was undoubtedly the first attempt. But after the abandonment of that venture there is no record of a regular sturgeon fishery until more than a century later. There is a tradition that before the revolution market-

[1] Burk, J. D., "History of Virginia," Vol. II., p. 17.

[2] Beverley, Robert, "History of Virginia," pp. 117–119.

[3] Watson, J. F., "Annals of Philadelphia," p. 46.

men at Trenton, then an important fishing center, packed sturgeon in barrels, shipping them to New York and to Philadelphia by ox team.[4] But until long after the colonial period, even in these places the roe was regarded as worthless except as feed for hogs or as bait for other fish. Furthermore, few people of the better class would eat the flesh, it being the food of servants and negro slaves.[5] The reason for this prejudice is not recorded, but it is not unlikely that it was similar to the early prejudice against the Connecticut River shad on the ground that it was food for Indians. It is true enough that this objection, though equally applicable, did not prevent the colonists from consuming large quantities of oysters. But the difference in the edible qualities of oyster and sturgeon combined with the no less great abundance of the more highly esteemed shad, might readily explain the inconsistency. At all events, that the strong prejudice did exist is beyond question, hence there seems to be room for some doubt about the importance of this Trenton fishery of the colonial period.

In the "History of the Fisheries and Fishing Industries of the United States," edited by G. Browne Goode, it is said that a large sturgeon fishery, employing a score of vessels in some years, was carried on in Maine during the early part of the eighteenth century, but was not followed continuously. The account does not state to what use the products were put nor where they found a market. Again in the first quarter of the last century a company of men located on a small island in Casco Bay and began fishing for sturgeon, sending the flesh in kegs to the West Indies. The business was soon suspended for unknown reasons, however, and although there was an abundance of sturgeon in the Kennebec there was no further attempt to utilize them, except for occasional home use, until many years later.[6]

Despite these various experiments at sturgeon fishing in different localities, the strong prejudice against the sturgeon flesh appears to have precluded the possibility of developing any regular market, and so prevented the growth of any important industry, until after 1850. It seems probable that the first approach to a regular and permanent fishery was developed in the Delaware River region. About 1830 and later, three Pennsylvania fishermen made a practise of taking sturgeon with nets and harpoons near the present town of Bristol, Pa. They also did some fishing about Dutch Island, near Bordentown, while on the other side of the Delaware a gill-net fishery was begun in 1853 at Penn's Grove, New Jersey.[7] That the occupation here was not very remunerative, however, can be seen from the fact that the fish rarely sold for more than 30 cents each and often as low as 12½ cents.

About the same time, a third attempt was made in the Kennebec

[4] *Fishing Gazette*, July 21, 1906, p. 679.

[5] U. S. Fish Commission Report, 1899, p. 370.

[6] Goode, Vol. V., Sec. 1, p. 699.

[7] U. S. Fish Commission Report, 1899, p. 370.

by representatives of a Boston firm, their object being to put up the roe for caviar and manufacture oil from the bodies. No difficulty was experienced in securing a supply of fish, 160 tons being caught the first season. The oil obtained was of excellent quality, but the experiment with the roe, one of the earliest in the country, was a failure, and after two seasons this venture went the way of its predecessors.

The Delaware River industry, evidently as a result of its proximity to New York and Philadelphia, where more convenient markets could be found among the foreign population and poorer classes, appears to have struggled along with a more or less precarious existence until about 1860. A few years prior to that date, the smoking of sturgeon flesh had been begun on a small scale in New York, and was followed by a similar custom in Philadelphia. Smoked sturgeon made a fairly good substitute for smoked halibut, and in this way a more or less regular demand for the flesh was for the first time created in the cities, being supplemented by the growing "wagon trade" carried on by peddlers who carted fish through the country districts.[8] The preparation of sturgeon roe for caviar had also been done successfully on a commercial scale and was perhaps even a more important factor in promoting the growth of the fishery. But as an important industry, the sturgeon fishery of Delaware River and Bay can not be said to have originated much before 1860 to 1870, at which time, so far as the records show, the Hudson River was the only other place where it gave promise of attaining extensive proportions. Maine was once more the scene of a sturgeon fishery in 1872, when local fishermen engaged in it, giving place two years later to a regular crew, headed by New York fishermen, catching and buying for the New York smoking and caviar establishments.[9] Important fisheries in the Hudson River existed prior to 1880, supplying local demands or the markets in Albany and New York. The former city is said to have taken such quantities of the flesh that it came to be known locally as "Albany beef," like the sobriquet "Charles city bacon" applied to sturgeon meat on the James River, in Virginia.[10] The Maine fishery, however, ceased to be important after five or six years, and never was revived, and the Hudson industry had declined greatly before 1880, because of the scarcity of fish. During this same period, Delaware River fishermen had developed a regular fishery for sturgeon about the mouths of the larger rivers along the South Atlantic coast, the most important localities being Albemarle Sound, Savannah River and Winyah Bay.[11] But regular fishing was also prosecuted near the mouths of the Altamaha, Satillas, Ogeechee, Edisto, Santee and the various streams enter-

[8] U. S. Fish Commission Report, 1899, p. 370.

[9] Goode, Vol. V., Sec. 1, p. 699.

[10] Goode, Vol. V., Sec. 1, p. 659.

[11] U. S. Fish Commission Bulletin, 1891, p. 355.

ing Winyah Bay.[12] In most cases the fishermen were from northern localities, going south to engage in the industry before the season opened in Delaware Bay, and sending their catch to the Savannah market, or to New York and Philadelphia, *via* Charleston or Savannah.[13]

In other localities, however, the sturgeon was somewhat slower in being rid of the strong prejudice against it, to which was added in many cases the bitter enmity of the fishermen because of the damage done to their nets by this powerful fish. The salmon fishermen of the Columbia River despised it as a worthless, destructive fish, and for many years whenever taken in the nets a sturgeon was usually killed or thrown out on the bank. Along the shores of the Great Lakes sturgeon were not used very much for food until after smoking of the flesh began at Sandusky about 1860, experiments in making caviar having been tried at that place five years earlier.[14] Before that time they had been so little valued that when it was possible to sell them they would not bring over 10 cents apiece,[15] while in most cases they were regarded as a nuisance, usually being taken out and thrown away. As late as 1872, in fact, sturgeon were taken in great abundance every autumn in the nets of the Green Bay region and were almost universally pulled into the boats and consigned to the offal heap.[16] From Virginia, also, comes the statement that less than three decades ago the roe was thrown away or used for fish bait, and such great quantities of meat were taken in the Potomac that there was absolutely no sale, the fish being piled like cordwood on the shore and farmers called on to cart them away for fertilizer.[17] In the face of these conditions, however, the sturgeon fishery by 1880 had become an important branch of the fishing industry in the Middle and South Atlantic States and in the Great Lakes. Successful smoking of the flesh and its use as a good substitute for smoked halibut had overcome much of the early prejudice and established a small, but growing, market for sturgeon meat, while the manufacture of isinglass from the bladder and, most potent of all, the increasing European demand for caviar, aided materially in establishing the industry on a profitable basis. Instead of being thrown out in heaps to rot as before, the multitudes of sturgeon in the Great Lakes were now turned to profit by the fishermen. Where in 1860 the sturgeon had supported only a tottering industry, confined largely to the Delaware River region, the year 1880 marked an industry widespread in its range and yielding nearly 12,000,000 pounds of products annually.

[12] Goode, Vol. V., Sec. 1, pp. 617–625.
[13] Goode, Vol. II., p. 506.
[14] U. S. Fish Commission Report, 1887, p. 249.
[15] *Loc. cit.*, p. 263.
[16] U. S. Fish Commission Report, 1872–73, p. 10.
[17] *Fishing Gazette*, January 20, 1906, p. 56.

For nearly two decades after 1880 the annual yield of sturgeon products did not fall below eleven or twelve million pounds, but as season followed season the same areas were not contributing the same proportion of the total. The accompanying table shows the catch for the various districts in different years. In 1880 the Great Lakes,

STATISTICS OF THE STURGEON FISHERY [18]

	1880		1890[19]	
	Pounds	Value	Pounds	Value
New England	....	....	2,800	$132
Middle Atlantic	1,719,558	$65,553	5,847,527	144,255
South Atlantic	1,055,150	58,899	487,787	10,374
Gulf	....	....	....	....
Pacific Coast	1,658,000[22]	....	2,309,294	38,019
Great Lakes	7,557,383[22]	....	4,289,759	148,360
Interior	....	....	....	....
	11,990,091		12,937,167	$341,140

	1897[20]		1904[21]	
	Pounds	Value	Pounds	Value
New England	21,310	$1,256	21,260	$2,112
Middle Atlantic	3,698,905	191,926	736,313	91,708
South Atlantic	1,042,230	56,178	238,855	25,483
Gulf	31,654	1,315	478,496	17,098
Pacific Coast	3,139,511	80,094	137,981	4,271
Great Lakes	1,176,818	111,389	638,898	53,017
Interior	2,250,209	62,693	1,008,408	38,355
	11,360,637	$504,851	3,260,211	$232,044

owing to the vast abundance of sturgeon in the shallow and warmer waters of Lakes Michigan and Erie, yielded more than three fifths of the total for the United States. Although complete statistics for the entire country are not available for any single year during the decade following 1880, there is ample reason for believing that the industry expanded and the products increased rapidly for several seasons. For example, the catch in the Lakes was only 410,000 pounds smaller in 1885 than it was in 1880,[23] and in 1888 the chief coastal areas, the

[18] Statistics from following sources: Goode, Vols. II., V., Sec. 1. Report of the U. S. Fish Commission, 1888; 1893, p. 146; 1895, p. 495; 1896, p. 576; 1899, pp. 109, 175, 372–80; 1900, pp. 200, 319; 1901, pp. 511, 580; 1902, pp. 440, 484; 1903, pp. 348, 416; 1904, pp. 648–51. Bulletin of U. S. Fish Commission, 1890, p. 78; 1891, p. 281; 1894, p. 350. Fisheries Documents 609, 620; Statistical Bulletin 183.

[19] Statistics are for years as follows: New England, 1889; all others, 1890.

[20] Statistics are for years as follows: New England, 1898; Pacific coast, 1895; Great Lakes, 1899; Interior Waters, 1895; others, 1897.

[21] Statistics are for years as follows: New England, 1905; Middle Atlantic, 1904; South Atlantic and Gulf, 1902; Pacific Coast, 1904; Great Lakes, 1903; Interior Waters, 1903.

[22] No values given.

[23] U. S. Bureau of Fisheries Report, 1904, pp. 649–51.

Middle Atlantic, South Atlantic and Pacific coast states, yielded an aggregate of nearly eight and a half million pounds as compared with less than four and a half million pounds in the earlier year.[24] Every pound of this increased coastal yield in 1888, however, was due to the expansion of the Delaware River and Bay fishery, which in that year produced over 6,400,000 pounds. But even this phenomenal catch is said to have been smaller than it had been a few years before.[25] It seems safe to conclude, therefore, that in 1885 the combined sturgeon catch in the Lakes and in the Delaware region alone was not less than 25 per cent. greater than the total product of the whole country in 1880. If this be true the total catch in the United States must have ranged at least somewhere above 16,000,000 pounds in 1885. It was the demand for caviar in European markets and especially in Germany which had more than anything else made the fishery profitable and caused it to rise almost in a single decade, 1875–1885, to an industry of important proportions among the valuable fisheries of the country.

By 1890, almost every district was beginning to show the effects of the vigorous fishing which had swelled the total catch during the early years of the decade. The declining supply was most marked in the lakes, where the catch had fallen off by nearly three million pounds in five years. The Middle Atlantic States then stood first, the quantity taken from the comparatively small expanse of Delaware Bay exceeding the entire lake catch by nearly a million pounds,[26] the total being over three times as great as it had been in 1880, but distinctly less than the amounts reported in the intervening years. In the South Atlantic States also there had been extensive declines in the sturgeon products,[27] but since the catch in these areas increased to a marked degree in subsequent years it seems necessary to suppose that the low catch of 1890 was due in part, at least, to other causes than scarcity of fish. Along the Pacific coast, on the other hand, marked expansion was taking place in the years preceding and subsequent to 1890, as the result of a successful sturgeon industry established on the Columbia River in 1888. Vast quantities of sturgeon had been observed by the fishermen ever since the salmon fishery had begun two decades before, but all that time the sturgeon had been looked on as a nuisance and "in most cases was knocked on the head and set adrift in the river."[28] The abundance of the supply available can be seen from the fact that two years after the business was started the catch rose to nearly 1,700,000 pounds, and to more than 3,000,000 pounds in 1892. This important increase in the Pacific coast district, combined with the greater extent of the Delaware

[24] U. S. Commission Report, 1888, "Statistical Survey of the Coast Fisheries of the United States."

[25] U. S. Fish Commission Bulletin, 1888, p. 278.

[26] U. S. Fish Commission Report, 1899, p. 372.

[27] U. S. Fish Commission Bulletin, 1891, p. 281.

[28] U. S. Fish Commission Report, 1893, p. 250.

fishery as compared with ten years before, accounts for the greater yield for the country in 1890.

Statistics of the sturgeon fisheries in the scattered inland waters of the country were collected for the first time in 1895 and added a little over 2,250,000 pounds to the total.[29] The major portion, over two thirds, of this quantity came from a single area—the Minnesota waters of the Lake of the Woods. The same year showed continued large catches in the waters of Washington and Oregon, though a comparison of the totals with the figures for a few years before indicates a growing scarcity of fish and an impending decline.[30] The Carolinas and Georgia, however, were again yielding as much as formerly, having recovered at least temporarily from the low condition of 1890. The activity in these three areas helped to offset the appalling decline which had continued uninterrupted in the lake region and the Delaware district, as indicated by the statistical surveys of 1897. The lakes in 1897 produced scarcely more than one fourth as much as they had in 1890, and New Jersey, which alone had yielded over 3,600,000 pounds in 1890, barely exceeded 1,000,000 pounds seven years later.[31] On account of these tremendous losses in the supply from the waters of early importance, the total yield of the country had fallen only a little more than half a million pounds below the figures for 1880, but over a million and a half pounds below the total for 1890, and at least six million pounds below the catch of 1885.

Two factors had played a leading part in maintaining the industry against such odds as are represented in the depletion of the Great Lakes and Delaware River sturgeon. First of all the rising price of caviar was a powerful incentive to pursue sturgeon fishing with increasing vigor wherever a profitable catch could be made. Caviar which had brought from $9 to $12 per keg of 135 pounds in 1885, was worth $20 five years later, $40 in 1894, and before the end of that decade had risen above $100 per keg.[32] Sturgeon roe was no longer fish bait and feed for hogs, and few sturgeon found their way to the offal heap, at least, until after the precious ova were removed. Flesh too was mounting upwards in price, reaching as high as 12½ cents per pound in 1896, where a decade and a half before sale had often been impossible at even one cent per pound. From 1882 to 1884 female sturgeon would bring as high as $2 each at the wharf, whereas fifteen years later the usual price was $30 to $35 each. In the spring of 1899, for example, 96 sturgeon at Bayside, New Jersey, brought $3,923, an average of a little over $40 apiece.[33] Nowhere else in the whole

[29] U. S. Fish Commission Report, 1895, p. 495.
[30] U. S. Fish Commission Report, 1896, p. 576.
[31] Bureau of Fisheries Report, 1902, p. 460.
[32] U. S. Fish Commission Report, 1899, p. 379.
[33] Pennsylvania Fish Commission Report, 1900, p. 171.

annals of commercial fisheries is there a parallel to this case of the sturgeon, rising as it did in less than a quarter of a century from a fish despised and ruthlessly destroyed on all sides to the highest rank of commercial value.

The high prices for caviar resulted in continued operations in the old localities even in the face of greatly reduced hauls. This condition is nowhere better illustrated than in the Delaware district, where the average catch per net dropped from 60 fish in 1890 to less than half that number six years later.[34] Yet in 1897 nearly 1,000 fishermen were operating over 150 miles of gill nets in the sturgeon fishery of Delaware Bay and the number of boats employed had actually increased.[35] At the same time operations were extended and expanded in every available new area to supply the growing demand and to profit from the rapidly rising prices. The sturgeon fishery in the Gulf States was begun at this time because of the increasing scarcity of the species in northern waters.[36] The south side of Long Island was the scene of an important fishery begun in 1892, producing more than half a million pounds of products five years later,[37] while the yield from interior waters, though steadily decreasing, was annually forming a larger proportion of the total output of the country. Only by most vigorous means was the total extent of the industry maintained anywhere near its former level, while the fishermen to eke out profits were endeavoring to utilize more of the sturgeon by the manufacture of oil and fertilizer from the carcass.

By 1897 the sturgeon fishery attained the highest point of its commercial value, over half a million dollars, while at the same time it appears to have reached its limit of endurance under the strain of incessant demand placed upon it. In the decade elapsed since then there has been only decline—decline almost universal and astounding in its extent. In many places, the sturgeon is practically extinct and in others, where once important fisheries were prosecuted, the industry is nearly abandoned. New York and Pennsylvania waters have almost ceased to yield sturgeon products despite the half million pounds from Long Island in 1897. The same condition appears in the Carolinas, while the species has entirely disappeared from the waters of Eastern Florida and Oregon. On the Pacific coast, as a whole, where more than 3,000,000 pounds were taken in 1895, less than four per cent. of that quantity was obtained in 1904. The Middle Atlantic area as a whole and the Great Lakes are now yielding less than one tenth the amount caught two decades ago. Lake St. Clair, which alone gave nearly a million pounds in 1880 has not produced more than 10,000

[34] U. S. Fish Commission Report, 1899, p. 371.

[35] *Ibid.*, pp. 379–80.

[36] Bureau of Fisheries Report, 1903, pp. 443, 445.

[37] Bureau of Fisheries Document 609, p. 29.

pounds in recent years, while the catch in Lakes Michigan and Erie has fallen to about one sixtieth of its former proportions. In the Delaware River district, the most prolific of all the sturgeon grounds ever developed in this country, the depletion of the supply has gone almost to the point of extinction. The total amount yielded from the nets of the three states bordering the river and bay has dropped from more than 5,000,000 pounds in 1890 to less than 350,000 pounds in recent years.[38] A quarter of a century ago these waters still literally teemed with sturgeon, and it was impossible to dispose of all that could be caught. Then it was not an uncommon thing to see 1,000 or more sturgeon on the wharf at Bayside, New Jersey, with shipments of five or six carloads in a day to New York or Philadelphia. In recent years to see a score of sturgeon on the wharf at one time has been a rarity enough to bring the fishermen from miles around to see them, and if five or six boxes are shipped at the same time the shippers think they are lucky. Less than twenty years ago 4,000 to 5,000 kegs of caviar were shipped annually from the Delaware district and dominated the market under the name of Russian caviar. But the total caviar output had fallen to 726 kegs in 1899,[39] and at Delaware City, an important center, where 422 kegs of caviar were prepared in 1895, only six kegs were obtained in 1901, with even less since then, while the price has been soaring above $1 per pound. It is a condition without parallel in the annals of fishing.

With the single exception of the smaller rivers entering the Gulf of Mexico, where the fishing for sturgeon dates only since 1897,[40] all the grounds show evidence of the same rapid depletion. On every hand, declines of 90 to 95 per cent. in the last decade or two mean only the one thing—that the end of the sturgeon is near unless the most active and rigorous protective measures are speedily adopted.

This amazing depletion of a fish once "marvelously abundant" must be regarded largely as a natural or at least inevitable outcome of the character of the fishery itself. More or less weight must, of course, be given to the amount of wanton destruction of the sturgeon by the river and lake fishermen of successive decades before the sturgeon fishery was established on a commercial scale. Certain injurious and wasteful methods of fishing have also been employed at times, the worst of which was the use of small mesh nets both by sturgeon fishermen and by others, destroying many young sturgeon, the use of the three-pronged grappling hook dragged over the spawning grounds, particularly at the eastern end of Lake Erie, and most of all the unrelenting pursuit of the fish during the spawning season. The object of the

[38] U. S. Fish Commission Report, 1888; 1896, p. 576; 1899, pp. 109, 372; 1901, pp. 511, 580; 1903, p. 345; 1904, p. 648.

[39] Pennsylvania Fish Commission Report, 1900, pp. 170–71.

[40] Bureau of Fisheries Report, 1903. pp. 443, 455.

fishery, however, has always been chiefly to obtain the roe for caviar. Hence the spawning time was the most favorable period for profitable operation, and the fishermen, with their characteristic disregard for the future, by incessant fishing practically eliminated natural reproduction. When the lake whitefish supply began to fail the fishermen were required by law to return the spawn to the spawning grounds, and when the Atlantic coast shad showed signs of depletion vigorous work at artificial propagation was largely capable of counteracting the effect of too much fishing. But the case of the sturgeon was quite different, in that the profitable prosecution of the fishery depended mainly on the amount of roe secured. In many cases, in fact, no other portion was utilized until comparatively recently, when the price of the flesh advanced. Obviously then a most serious difficulty stood in the way of the adoption of those measures which had benefited fisheries for other species. The high value of the hard ova to the fishermen and their inability to use the soft or ripe ova in caviar have meant the most vigorous efforts to secure the roe before it became soft. The United States Fish Commission, and the states of Pennsylvania, New Jersey and Delaware, have repeatedly tried sturgeon hatching individually and in cooperation, but the difficulty experienced in securing ripe spawn and milt at the same time has brought failure.[41] The fact is, in the Delaware district, at least, the species is so nearly extinct, and males so scarce, that even when ripe ova are secured a male may not be taken for several days or too late to be of any use. It is hard to see how this condition can be easily remedied. With artificial propagation more or less impracticable and natural reproduction reduced to an absolute minimum, the fate of the sturgeon is obvious.

It is true, however, that some efforts have been made to prevent the complete extermination of the sturgeon and to protect the existing remnants of the formerly important fishery. The principal efforts have been made through legislative action placing certain restrictions on the operations of the fishermen. These restrictions fall into two groups, first, making it unlawful to take sturgeon under a given size, and second, prohibiting all sturgeon fishing at certain seasons. The states bordering on the Great Lakes furnish the best illustration of the first group of laws. Ohio in 1896 prohibited the capture of sturgeon less than 3½ feet long; Pennsylvania passed a similar law in 1901, and New York adopted a minimum length of 3 feet in 1902. Michigan and Wisconsin, on the contrary, based their restrictions on weight, the former, in 1897, setting 15 pounds as the lawful size, and the latter, in 1903, prohibiting the capture of sturgeon under 8 pounds.

These laws do not seem to have produced the desired result or in

[41] Bureau of Fisheries Report, 1902, p. 460. Pennsylvania Fish Commission Report, 1905, p. 64; 1906, p. 23.

fact any important result at all, for the fishery has continued to decline steadily since the laws were enacted. The trouble, however, lies not so much in the provisions of the law itself, as it does in the difficulty of adequate enforcement. The Lake areas are in this respect no different from other localities, since laws protecting the young sturgeon of the Delaware have been in operation from 1891, yet the fishery in those waters has declined at an extremely rapid rate, and to a greater extent than in almost any other region.

The other alternative of statutory protection, the close season, has received less common trial because the only time at which a close season has any value is during the spawning period, and at that time the fishery is most profitable. The scarcity of such laws is probably due to the fact that restrictive legislation affecting the fisherman's profits has always been notoriously difficult to pass. Georgia, however, in 1901 prohibited catching of sturgeon in all waters of the state for a period of five years. Minnesota in 1905 adopted a close season from March 1 to May 1 of each year, but at the next session of the legislature the Georgia example was followed in the provision for a close season at all times until June 1, 1910. This sort of law seems to afford the only real remedy for existing conditions. Complete prohibition is, of course, much easier to enforce than partial prohibition, because where sturgeon roe can be legally taken at all the carcass can be disposed of readily and it then becomes a difficult matter to prove that the fish from which the roe was taken was undersized or underweight.

With the difficulties confronting artificial hatching and the adequate enforcement of restrictive measures, the future of the sturgeon fishery depends on the absolute cessation of fishing for a period of years during which the supply can be replenished through natural reproduction. Otherwise the total extinction of the species is as inevitable as was the depletion of the supply. This chain of conditions is not peculiar to the United States, but has prevailed in all the older localities wherever the fishery has been prosecuted. Yet it seems scarcely comprehensible that a fish so widely distributed through the country, so abundant, and so little used less than three decades ago, has so rapidly disappeared that the end is already in sight. The higher the price of caviar, the more vigorous the pursuit of the sturgeon and the more quickly the end will come. Under the present conditions it is only a question of a few years until the day of the sturgeon fishery will have passed.

FOREIGN ASSOCIATES OF NATIONAL SOCIETIES

By Professor EDWARD C. PICKERING

HARVARD COLLEGE OBSERVATORY

MEMBERSHIP in societies is, in general, a poor test of the qualifications of a scientific man. The case is very different, however, if we consider only the foreign associates of the principal national societies or academies of the world. Their organization differs in different cases, but, in general, each is divided into several sections, of which that relating to the physical and natural sciences will alone be considered here. The members are divided into two or more classes which are called by various names. First, resident members, who live in the vicinity, pay fees and practically own the society. Secondly, foreign associates, who, as they have few duties or rights, and as the position is a purely honorary one, are selected wholly for eminence in a particular science. Their number is generally limited and on the death of one, a typical method of selecting a successor would be as follows: The matter would first be referred to a committee of resident members in the same department of science. These specialists would report one or more candidates, and the final selection would be made by the entire body of resident members. Doubtless injustice may be done in individual cases, but it is hardly possible that an unworthy person could secure membership in many foreign countries. It is sometimes stated by those unfamiliar with the facts, that a candidate can not be elected without personal effort on his own part. This is incorrect, as to my personal knowledge in at least half a dozen cases the notice of his election was the first intimation a candidiate had that his name was under consideration. It is possible that, in some cases, a candidate may have aided his election, but it would be a dangerous experiment, as many persons would vote against him for this reason only.

Ten countries, not including colonies, have a population of more than twenty millions: China, 432,000,000; Russia, 146,800,000; United States, 86,400,000; German Empire, 60,600,000; Japan, 49,700,000; Austro-Hungarian Empire, 47,000,000; Great Britain, 41,500,000; France, 39,000,000; Italy, 32,500,000; Congo Free State, 30,000,000. The population of Brazil is 19,900,000; of Spain, 18,900,000; of Mexico, 13,600,000. Omitting these, and China, Japan and the Congo Free State, we have the seven great nations of the world. The national or principal scientific societies of each of these countries is given in Table I. The name of the country, the name of the society, the year of its foundation, and the date of the list of members employed in the following discussion are given in the successive columns.

TABLE I.

SOCIETIES

Country	Society	Founded	List
Russia.	Imperial Academy of St. Petersburg.	1725	1903
United States.	National Academy of Sciences.	1863	1908
Germany.	Royal Prussian Academy of Sciences.	1700	1908
Austria.	Royal Academy of Sciences.	1847	1907
Great Britain.	Royal Society of London.	1645	1908
France.	Institute of France.	1795	1908
Italy.	Royal Academy of the Lincei.	1603	1908

A list was next prepared of the foreign associates of each of these societies. It appears that there are 87 persons thus honored by two or more societies. Their names are given in the first column of Table II., in alphabetical order. The present residence is given in the second column. The department of science is given in the third column, generally taken from that assigned by the Institute of France, or the Academy of the Lincei. These classifications, which are nearly identical, are geometry, mechanics, astronomy, geography (including navigation), physics, chemistry, mineralogy, botany, agriculture, zoology (including anatomy), and medicine (including surgery). The year of birth is given in the fourth column, and the age at the time of election in the following columns. The letters. R, U, G, A, B, F and I represent the seven societies named above, respectively. The age is placed in italics to indicate resident membership. Thus, italics are used, in the column headed R, in the case of all Russians. No account has been taken of elections or deaths occurring after January 1, 1908.

In using Table II., it is extremely difficult to treat all nationalities with equal fairness. Thus, a resident in one of the seven great countries can be a foreign associate of only six of the societies. A Russian could never be a foreign associate of the Russian Society, while a Swede might be an associate of all seven. The numbers in italics in Table II. are much smaller than the others, which shows that less eminence is required for election as a resident member, than as a foreign associate, or perhaps that a man's work is better known at home than abroad. In a few cases, a man is elected into a foreign society who is not a member of the home society. This seldom occurs except in Germany, where a Bavarian, for instance, might be elected into the Austrian Society, before he was elected into the Prussian Society. Complications also occur when a resident member of a society moves into another country. Fortunately, these conditions affect a few men only. On the whole, the simplest and fairest plan seemed to be to

Table II.

List of Members

Name	Country	Science	Birth	R	U	G	A	B	F	I
Agassiz, A.	U. S.	Zoology	1835	...	*31*	60	54	56	52	53
Auwers, A.	Prussia	Astronomy	1838	35	45	*28*	56	41	54	50
Bachlund, O.	Russia	Astronomy	1846	*37*	57	...	...	...	49	...
Baeyer, A. von	Bavaria	Chemistry	1835	57	63	*39*	50	50	51	59
Becquerel, A. H.	France	Physics	1820	...	85	84	...	...	*69*	83
Beneden, E.	Belgium	Zoology	1846	56	...	41	56	...	55	53
Bornet, E.	France	Botany	1828	74	73	...	...	...	*38*	...
Brögger, W. C.	Norway	Mineralogy	1851	47	52	...	...	51	53	...
Butschli, O.	Baden	Zoology	1848	46	...	*49*	56	...	...	...
Cannizaro, S.	Italy	Chemistry	1826	63	...	62	63	63	69	*47*
Chauveau, J. B. A.	France	Agriculture	1827	...	...	...	...	62	*59*	63
Christie, W. H. M.	England	Astronomy	1845	47	...	...	...	*36*	51	...
Darboux, J. G.	France	Geometry	1842	53	...	55	65	60	*42*	48
Darwin, G. H.	England	Geography	1845	...	59	...	...	*34*	62	52
DeVries, H.	Holland	Agriculture	1848	...	56	...	...	57	...	54
Ehrlich, P.	Prussia	Medicine	1854	...	50	...	...	...	...	53
Engelmann, T. W.	Prussia	Medicine	1843	...	...	*55*	52	...	52	58
Fischer, E.	Prussia	Chemistry	1852	47	52	*41*	50	47	48	47
Gaudry, J. A.	France	Mineralogy	1827	...	...	73	...	68	*55*	70
Geikie, A.	England	Mineralogy	1835	...	66	54	60	*30*	56	63
Gill, D.	England	Astronomy	1843	42	55	47	...	*40*	53	63
Gordan, P.	Bavaria	Geometry	1837	...	...	*63*	...	...	67	67
Groth, P.	Bavaria	Mineralogy	1843	40	62	...	...	...	...	62
Haeckel, E.	Saxony	Zoology	1834	...	...	...	38	...	...	65
Hann, J.	Austria	Geography	1839	51	...	50	*33*	...	...	...
Heim, A.	Switzerland	Mineralogy	1849	...	...	...	...	47	57	...
Helmert, F. R.	Prussia	Geography	1843	...	...	*57*	...	...	56	54
Hering, E.	Saxony	Medicine	1834	...	...	...	61	68	...	65
Hilbert, D.	Prussia	Geometry	1862	...	45	...	...	...	...	41
Hill, G. W.	U. S.	Astronomy	1838	...	*36*	...	...	64	65	...
Hittorf, W.	Prussia	Physics	1824	...	...	*62*	...	...	76	80
Hoff, J. H. van't.	Prussia	Chemistry	1852	43	49	*44*	44	45	53	49
Hooker, J. D.	England	Botany	1817	41	66	54	...	*30*	49	58
Huggins, W.	England	Astronomy	1824	77	80	71	...	*41*	50	59
Jordan, M. E. C.	France	Geometry	1838	57	...	...	...	...	*43*	57
Karpinski, A.	Russia	Mineralogy	1847	*49*	...	...	50	...	...	51
Klein, F.	Prussia	Geometry	1849	46	49	...	51	36	48	34
Koch, R.	Prussia	Medicine	1843	41	60	*61*	60	54	60	45
Kohlrausch, F.	Prussia	Physics	1840	54	61	*55*	...	55	...	59
Kronecker, U.	Switzerland	Medicine	1839	..	62	...	...	...	...	58
Lancaster, E. R.	England	Zoology	1847	48	56	...	...	*28*	52	51
Leydig, F. von	Wurtemberg	Medicine	1821	76	...	*66*	...	80	...	...
Lippman, G.	France	Physics	1845	...	...	55	...	51	*41*	...
Lister, J.	England	Medicine	1827	...	71	...	70	*33*	66	...
Lockyer, J. N.	England	Astronomy	1836	...	...	...	...	*33*	37	47
Lorentz, H. A.	Holland	Physics	1853	...	53	52	...	52	50	49
Mascart, E. E. N.	France	Physics	1837	54	...	58	...	55	*47*	62
Michelson, A. A.	U. S.	Physics	1852	...	*36*	...	...	50	48	54
Mittag-Leffler, G.	Sweden	Geometry	1846	50	...	...	...	50	54	53
Nansen, F.	Norway	Geography	1861	37	...	...	...	...	34	39
Nathorst, G.	Sweden	Botany	1850	51	...	50	36	...	...	...
Neumayer, G. B. von	Saxony	Geography	1826	...	...	*70*	77	73	...	...
Newcomb, S.	U. S.	Astronomy	1835	61	*34*	48	69	42	39	60
Noether, M.	Bavaria	Geometry	1844	...	...	*52*	...	...	59	47
Ostwald, W.	Saxony	Chemistry	1853	43	53	*52*	51	...	...	...
Pawlow, I. P.	Russia	Medicine	1854	*47*	...	...	...	53	...	53
Pfeffer, W. F. P.	Saxony	Botany	1845	...	58	*44*	59	52	55	54
Pflüger, E. F. W.	Prussia	Medicine	1828	66	...	*72*	...	60	...	71
Picard, E.	France	Geometry	1856	39	47	42	...	...	*33*	45
Pickering, E. C.	U. S.	Astronomy	1846	...	*27*	60	...	61	61	55

TABLE II.—*Continued*

LIST OF MEMBERS

Name	Country	Science	Birth	R	U	G	A	B	F	I
Poincaré, H.	France	Geometry	1854	41	44	42	49	40	*33*	34
Ramsay, W.	England	Chemistry	1852	49	52	44	51	*36*	43	55
Ranvier, L. A.	France	Zoology	1835	47	...	...	...	...	*42*	53
Rayleigh, J. W.	England	Physics	1842	54	56	54	60	*31*	48	59
Retzius, G.	Sweden	Zoology	1842	53	...	51	59	65	53	65
Righi, A.	Italy	Physics	1850	46	...	...	...	57	...	*48*
Roscoe, H. E.	England	Chemistry	1833	...	...	...	...	*30*	53	74
Rosenbusch, H.	Baden	Mineralogy	1836	...	68	*51*	68	...	63	65
Sars, G. O.	Norway	Zoology	1837	59	...	61	...	...	...	...
Schiaparelli, G. V.	Italy	Astronomy	1835	39	...	44	39	61	44	*40*
Schultze, F. E.	Prussia	Zoology	1840	55	...	*44*	44	...	...	...
Schwarz, H. A.	Prussia	Geometry	1843	54	...	*49*	...	...	52	45
Schwendener, S.	Prussia	Botany	1829	...	...	*50*	70	...	71	70
Strasburger, E.	Prussia	Botany	1844	...	54	*45*	...	57	56	49
Suess, E.	Austria	Mineralogy	1831	70	67	69	*36*	73	58	52
Thompson, J. J.	England	Physics	1856	...	47	...	...	*28*	...	47
Thomsen, J.	Denmark	Chemistry	1826	...	...	74	...	76	...	57
Treub, M.	Java	Botany	1851	...	...	49	...	48	37	...
Tschermak, G.	Austria	Mineralogy	1836	...	...	45	*39*	...	61	47
Valdeyer, H. G. G.	Prussia	Zoology	1836	58	...	*48*	71	...	68	...
Van der Vals, J. D.	Holland	Physics	1837	...	...	63	...	...	63	66
Van Tieghem, P. E. L.	France	Botany	1839	...	...	...	51	...	*38*	66
Walcott, C. D.	U. S.	Mineralogy	1850	45	*46*	...	...	...	...	51
Warming, J. E. B.	Denmark	Botany	1841	...	...	58	...	...	63	65
Wiesner, G.	Austria	Agriculture	1838	...	...	61	*54*	...	...	64
Zeuthen, H. G.	Denmark	Geometry	1839	...	...	...	...	...	61	63
Zirkel, F.	Saxony	Mineralogy	1838	...	65	*49*	45	59	...	61

count the numbers in the last columns of Table II., thus including the home societies. The results are nearly the same as if we omit the home societies and diminish the numbers in each case by one. The formation of the table by requiring membership in at least two foreign societies is a slight advantage to those not resident in the seven great countries, but they lose when italic numbers are included. The table furnishes the means of making a count with any other conditions, but it is not probable that the general conclusions would thus be changed.

Before discussing the results of Table II., it may be well to apply certain tests to it. The English Order of Merit includes the names of Huggins, Lister, Hooker and Rayleigh. They are all contained in Table II. and are members of 6, 4, 6 and 7 societies, respectively. Great care is taken in awarding the Bruce medal. The six living medalists are included in Table II., the number of societies being 7, 7, 6, 6, 6 and 5, respectively.

Four of the seven societies confer a special honor on a few of their foreign associates by granting them the privileges of resident members, or by placing them in a special class of honorary members. The names and years of elections are as follows: Russia: Newcomb, 1896; Nansen, 1898; Suess, 1901; Schmoller, 1901; Wundt, 1902. Prussia: Hittorf, 1900; Suess, 1900; Pflüger, 1900; Hooker, 1904; Schiaparelli, 1904; Baeyer, 1905. Austria: Schiaparelli, 1893;

Hering, 1896; Lister, 1897; Hoff, 1903; Koch, 1903; Agassiz, 1907; Baeyer, 1907. France: Lister, 1893; Newcomb, 1895; Suess, 1900; Hooker, 1900; Schiaparelli, 1902; Koch, 1903; Agassiz, 1904. As the number selected is nearly the same in each of the four societies, it might be expected that several of the men would be chosen by all. Of the fifteen men, no one was selected by all four societies, two were selected by three, six by two, and according to Table II. with one exception belong to either six or seven societies. Seven men were elected as honorary members of one society only, and the names of two of them do not appear in Table II.

Nearly every other honor than that of foreign associate depends on other considerations than eminence. Thus, honorary degrees from the great universities are often regarded as an excellent test of distinction. But many universities give degrees only when candidates are present, and accordingly, one who always remained at home, from illness or other causes, would be at a great disadvantage. This is still more markedly the case with decorations, which are often given for services rendered, or to the representative of a country, wholly independently of his personal eminence.

Table III. gives for each country represented in Table II., the name, the population, the number of members belonging to 7, 6, 5, 4, 3 and 2 societies, respectively, and to all combined. The total number of memberships is given in the next column. Thus, if there were two members each belonging to 5 societies, and one belonging to 4, the total membership would be 14. The average number, or the number of memberships divided by the number of members, is given in the following column. The population expressed in millions divided

TABLE III.

COUNTRIES

Country	Population	7	6	5	4	3	2	No.	Soc.	Av.	Mill.
Prussia	37,300,000	4	1	2	5	3	2	17	77	4.5	2.0
England	30,800,000	2	4	1	2	4	.....	13	63	4.8	2.4
France	39,000,000	1	1	2	2	6	.....	12	49	4.1	3.0
United States	86,400,000	1	1	1	1	2	.....	6	28	4.7	14.4
Saxony	4,500,000	.....	1	1	1	2	1	6	23	3.8	0.8
Austria	47,000,000	1	.....	.....	1	2	.....	4	17	4.2	11.8
Bavaria	6,500,000	1	.....	.....	.....	3	.....	4	16	4.0	1.6
Italy	32,500,000	.....	2	.....	.....	1	.....	3	15	5.0	10.8
Sweden	5,300,000	.....	1	.....	1	1	.....	3	13	4.3	1.8
Holland	5,600,000	.....	.....	1	.....	2	.....	3	11	3.7	1.9
Russia	146,800,000	.....	.....	.....	.....	3	.....	3	9	3.0	48.9
Norway	2,200,000	.....	.....	.....	1	1	1	3	9	3.0	0.7
Denmark	2,600,000	.....	.....	.....	.....	2	1	3	8	2.7	0.9
Baden	2,000,000	.....	.....	1	.....	1	.....	2	8	4.0	1.0
Switzerland	3,300,000	.....	.....	.....	.....	.....	2	2	4	2.0	1.6
Belgium	7,100,000	.....	.....	1	.....	.....	.....	1	5	5.0	7.1
Wurtemberg	2,300,000	.....	.....	.....	.....	1	.....	1	3	3.0	2.3
Java	23,700,000	.....	.....	.....	.....	1	.....	1	3	3.0	28.7
All	489,900,000	10	11	10	14	35	7	87	361	4.1	5.6

by the number of members, is given in the last column of the table. Thus, Prussia, which has a population of 37,300,000 furnishes 4 men who are members of all 7 societies, 1 of 6, 2 of 5, 5 of 4, 3 of 3, and 2 of 2, making 17 in all. The number of memberships is 77, or an average of 4.5 societies to each member. On the average, one Prussian in 2,000,000, appears in Table II.

From an examination of Table III. it appears that, with the exception of one botanist from Java, who should perhaps be added to the group from Holland, no member resides in Asia, Africa, South America or Oceanica. With the same exception, no member comes from a colony or subsidiary country. The only members from North America are from the United States, and no members come from Scotland, Ireland or Wales. The number from the United States is no greater than that from Saxony which has about one twentieth the population. This is in part offset by the fact that the two English speaking nations, England and the United States, show a higher average number of societies per member than any other nations except Italy and Belgium. The very small ratio of members to population in Russia is largely due to the vast sparsely settled tracts of that country where advanced intellectual work is impossible.

Grouping the members according to cities, we have, Paris, 12; London, 10; Berlin, 10; Vienna, 4; Leipzig, 4; Stockholm, 3; St. Petersburg, 3; Copenhagen, 3. It will be noticed that, with the exception of Leipzig, each of these cities is the capital of its country. All the members from France, Austria, Sweden, Russia, Denmark and Java come from the capitals of those countries. Of the entire 87, 58 or nearly two thirds reside in capital cities. The average membership of these men is also higher, being 4.3 for those in capitals and 3.9 for the others. Ten cities contain two members each, and seventeen, one each.

A grouping according to the sciences is given in Table IV., in a form similar to Table III. The successive columns give the name of the science, the number of members in 7, 6, 5, 4, 3 and 2 societies, respectively, the total number of members, the total number of societies, the average number of societies per member, and four columns indicating the country to which the members belong. The first of these columns headed G, for Germany, includes Prussia, Saxony, Bavaria, Baden and Wurtemberg; E includes England and the United States; F, France; M, the other countries.

In eight of the sciences, the number of members is fairly distributed, varying from 8 to 11. None appear in mechanics, 3 only in agriculture, and 5 in geography. The grade, or average membership is remarkably high in chemistry, 5.5, with astronomy second, 4.9. The average for all is 4.1. Of the 10 members belonging to all seven societies 4 are chemists. The distribution according to nations is

Table IV.

Sciences

Name	7	6	5	4	3	2	M	S	Av.	G	E	F	M
Geometry	1	2	1	2	3	2	11	45	4.1	5	.....	4	2
Mechanics	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Astronomy	2	3	1	.....	4	1	10	49	4.9	1	7	.....	2
Geography	.....	.....	.....	1	4	.....	5	16	3.2	2	1	.....	2
Physics	1	.....	3	2	5	.....	11	45	4.1	2	3	3	3
Chemistry	4	1	.....	1	2	.....	8	44	5.5	4	2	.....	2
Mineralogy	1	1	2	3	3	1	11	46	4.2	3	2	1	5
Botany	.....	2	1	1	5	.....	9	36	4.0	3	1	2	3
Agriculture	.....	.....	.....	.....	3	.....	3	9	3.0	.....	.....	1	2
Zoology	.....	2	2	1	3	2	10	39	3.9	4	2	1	3
Medicine	1	.....	.....	3	3	2	9	32	3.6	6	1	.....	2
All	10	11	10	14	35	7	87	361	4.1	30	19	12	26

instructive. In geometry, France has 4; Prussia, 3; Bavaria, 2; England, 0; United States, 0. In astronomy, England has 4; United States, 3; Prussia, 1; France, 0. In medicine, Prussia has 4; Bavaria, 2; England, 1; France, 0; United States, 0.

A grouping according to the seven societies is given in Table V. The name of the country is given in the first column, followed by the number of members belonging to 7, 6, 5 4, 3 and 2 societies, respectively. Of course, the number belonging to 7 societies, 10, is the same for all. The total number of members in Table II. is given in the next column, followed by the number in each society who have so far failed to be elected into any other society (except perhaps that of their own country) and are, therefore, not included in Table II. The sum of the last two columns is given in the next column, and gives the total number of foreign associates. The ages of the youngest and oldest foreign associate in Table II., at the times of their election into each society, are given in next two columns.

Table V.

Societies

Society	7	6	5	4	3	2	II.	T	All	Y	O
Russia	10	8	5	6	16	1	46	30	76	35	77
United States	10	7	8	6	7	3	41	5	46	44	85
Germany	10	10	9	9	16	1	55	14	69	41	84
Austria	10	8	3	6	9	1	37	9	46	36	77
Great Britain	10	11	7	7	15	1	51	8	59	36	80
France	10	11	8	12	19	2	62	24	86	34	76
Italy	10	11	10	10	23	5	69	39	109	34	83
All	70	66	50	56	105	14	361	129	490	34	85

The order in which members were elected into each society, furnishes a test of the care with which candiadtes were selected. Thus, if the ten members of all seven societies had been elected into one society first, and afterwards into all the others, we should say that that society had displayed great skill and discernment in its selection. In fact, the Imperial Academy of St. Petersburg elected four of these men before their talents were discovered by any other foreign society on this list, and two of them before they were elected by the home society. If one society was always the last to elect we should suspect that it awaited the judgment of others, in which case its choice would have little value as an independent opinion. It might, however, be due to other causes, as, for instance, a higher standard, if its total membership was less. A society which elected many members who were never elected into any other would appear to show poor judgment, although other conditions might enter in particular cases. Thus, every member must, for a time belong to one society only. The failure to detect marked differences by these tests confirms the view that the selections are made independently and fairly.

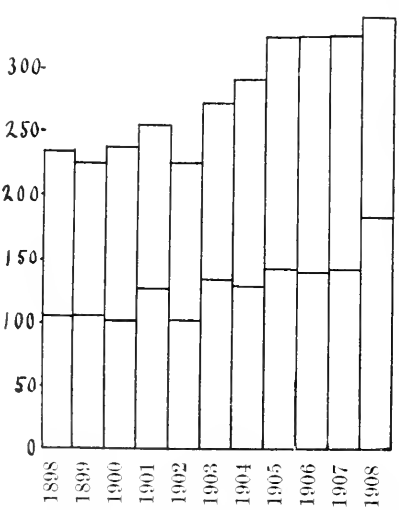
An examination of Table II. reveals some interesting cases. One member was elected into the six foreign societies in five years, while with another this period extended over thirty years. One was elected into all seven societies before he was fifty years old. One has been elected into the six foreign societies for eight years, and has not yet been elected into the home society. One was elected into three foreign societies before he was forty. Three persons have been elected into a foreign society after attaining the age of eighty, and ten before they were forty. About two thirds were elected into foreign societies between the ages of forty-five and sixty-five. On the average, these men were elected into their first foreign society about eight years after election into the home society. The successive elections then took place at average intervals of three years and a half. The oldest member is ninety-one, the youngest forty-six. Many other conclusions regarding age might be drawn, such as its relation to country, science or society, but no striking differences have been noticed.

The most important conclusions to be drawn by inhabitants of the United States, are that the representation per million inhabitants is less than a fifth that of the principal countries of Europe. We have no representative in mathematics or medicine, while in astronomy we have three out of ten members. The explanation is not hard to find. While immense sums are spent on higher education in this country, the endowment for advanced research is comparatively small. Astronomy is almost the only science having institutions devoted to research, and in which a large part of the time and energy is not expended in teaching. Of the six American members, five have occupied positions in which no teaching was required, but their entire time was supposed to be devoted to original investigation.

THE PROGRESS OF SCIENCE

DOCTORATES CONFERRED BY AMERICAN UNIVERSITIES

For the past eleven years there has been published in *Science* each summer an article on the degrees of doctor of philosophy and doctor of science awarded by American universities. It appears from these statistics that during this period 42 institutions have given this highest academic degree to 3,093 students. The number in each consecutive year is represented graphically by the height of the column in the accompanying figure. It thus appears that, with fluctuations from year to year, there has been a decided increase in the number of those officially designated as competent to teach and carry forward research work. The annual number first exceeded 250 in 1901 and 300 in 1905. After remaining stationary for about three years, it is this year 378. The middle lines in the columns represent by their distance above the base line the number of degrees in the natural and exact sciences, the balance of the space to the top of the column representing the number in the so-called humanities, including under this term history and political science. It thus appears that nearly but not quite half the degrees are given in the sciences and that there is a slight tendency for the sciences to gain on the humanities.



Doctorates conferred by American Universities

Three fourths of the 3,093 degrees have been conferred by seven universities as follows: Chicago, 410; Harvard, 380; Columbia, 377; Yale, 350; Johns Hopkins, 333; Pennsylvania, 257; Cornell, 203. The universities of the Atlantic seaboard, with Chicago, thus hold the position that Germany had twenty years ago. As Americans then frequented the German universities for advanced work, so now they tend to go to these seven universities which are private corporations, though perhaps Cornell and Pennsylvania are on the way to become state institutions. The great state universities of the central and western states will probably witness a large development of their graduate schools in the course of the next ten years, and the south will follow the same course in the following decade. Wisconsin gave 17 degrees this year and 19 last, more than double the average for the preceding ten years. Illinois, which this year received the first special appropriation made to a state university for graduate work, conferred five degrees, as many as had been conferred in the preceding ten years. Michigan, Minnesota and California have, however, remained nearly stationary.

About twice as many degrees are conferred in chemistry as in any other science. The numbers have been: chemistry, 374; physics, 177; zoology, 172; psychology, 157; mathematics, 144; botany, 137. There is then a drop to geology with 76, physiology with 48 and astronomy with 35. University work in chemistry is often a professional course for the chemical analyst or engineer and is thus not altogether parallel with the other sciences. It would be well if similar conditions obtained in engineering and the medical sciences, so that there would be larger numbers from which those competent to undertake research work might be selected.

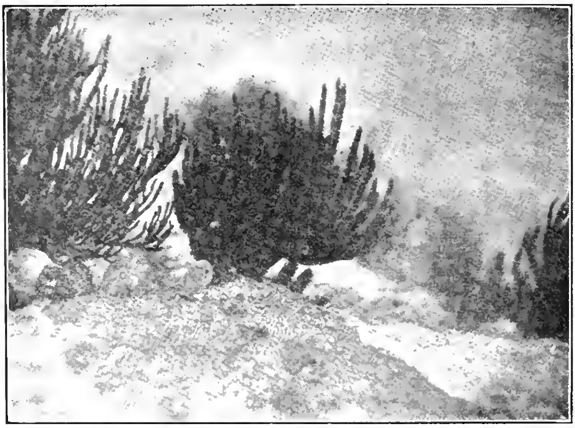
The universities differ in the relative emphasis placed on the sciences and the humanities. Thus at Cornell and the Johns Hopkins nearly sixty per cent. of the degrees are in the sciences, whereas at Harvard, Yale, Columbia and Pennsylvania the percentage is about forty. At Chicago the percentage is 49, at New York University it is only nine, and at Boston University only two. It is commonly supposed that the state universities are mainly occupied with the utilitarian sciences, and it is interesting to note that at Wisconsin, Michigan and Minnesota, respectively, 77, 60 and 70 per cent. of the degrees are in the humanities.

The three or four hundred young men added each year to those engaged in the advancement of science and learning are probably the most important factor in our civilization. Not more than half of them will accomplish anything after their doctor's theses, but the others may perhaps have their places filled by those who enter research work otherwise than by the ordinary academic routine. When we remember, however, that about 5,000 physicians and lawyers are graduated each year, the number taking the doctorate of philosophy seems to be small —not in proportion to the population and wealth of the country. There are some 25,000 professors and teachers in our colleges and universities and some 35,000 in the secondary schools; then there are increasing numbers of positions in the government service and elsewhere. The supply of men of the right kind does not equal the demand, and one of the most serious problems that confronts us is to find methods to increase the numbers and improve the quality of those engaged in scientific research.

AERIAL NAVIGATION

The center of interest—dramatic, practical and scientific—at present is in the demonstrations of aerial navigation now being made in France and here, especially by Mr. Wilbur Wright at Le Mans and by Mr. Orville Wright at Fort Myer. But the changes are so rapid—at the time of this writing Mr. Orville Wright has broken the record four times in four consecutive days—that only the daily newspapers can follow them. A scientific journal, however, should not go to press without an expression of admiration for the work of those who have so successfully applied scientific principles to the solution of practical problems, and it is not chauvinistic to betray satisfaction in the fact that the United States, in the scientific and applied work of Langley, Chanute and Bell and now in the practical success of the Wright brothers, has led the way.

It may be that flying-machines will only be used in war and in sport, but history has shown time after time that it is not safe to set limits to what science can accomplish. It almost seems to be a longer step from Langley's first experiments to what the Wright brothers have now done, than from this to complete mastery of aerial navigation. It would of course be impossible to accomplish this otherwise than through gradual progress in many directions. What is most needed at present is an engine of increased efficiency for its weight. Should this be devised, the problem would be much simplified. The dangers of aerial navigation are more obvious than real. It is now safer to go down to the sea in ships than to ride along a road on a horse. There is plenty of room in the



Examples of Submarine Photography.

air, and it may be found in the end that this advantage will more than counterbalance the chances of falling to the earth. However these things may be or whatever may happen or not happen, there is every reason to congratulate Messrs Orville and Wilbur Wright on their great achievement and on the careful scientific research which preceded it and on which it rests.

This is true in spite of the catastrophe that has occurred since these words were put in type. It appears that government officials are responsible for requiring the premature delivery of an aeroplane that would carry two persons. To an outsider it would seem that ballast should have been tried, and that protective clothing should have been worn.

THE PHOTOGRAPHY OF AQUATIC ANIMALS IN THEIR NATURAL ENVIRONMENT

At the seaside laboratory of Roseoff, in 1893 and subsequently, Dr. L. Boutan made the first submarine photographs by means of a submerged camera. He was not successful with a camera immersed directly in sea water, owing to the lack of a suitable lens, but got clear and good photographs with cameras enclosed in water-tight boxes, both with sunlight and in deeper water with the use of the magnesium flash-light and electric arc lamps. Since that time excellent aquatic photographs in aquaria have been made by Dr. R. W. Schufeldt, Mr. A. R. Dugmore and others, but the photography of fishes and other subaquatic life has by no means reached the degree of perfection that has recently been obtained in photographing birds and wild mammals in their natural habitats.

Professor Jacob Reighard, in a recent bulletin of the Bureau of Fisheries, has taken up the subject and describes methods of subaquatic photography, both when the camera is outside the water and when it is submerged. The former method must be used when the water is shallow, and good results can be secured when ways are found by which the light reflected from the surface of the water is cut off and a smooth surface is obtained. In deep water, however, and for many purposes it is necessary to use a submerged camera. Professor Reighard describes the apparatus he used at the Tortugas, and examples of the photographs taken are here reproduced. According to Professor Reighard's description, in the upper picture a butterfly-fish (*Chætodon capistratus*) with a stripe through the eye and an eye-like spot on the tail is seen over a flat expanse of coral (*Meandrina*) and at the base of a large, branching

ALBRECHT VON HALLER.

Eminent as physiologist, botanist and poet, the two hundredth anniversary of whose birth will be celebrated by the University of Bern on October 15.

gorgonian. The photograph was taken while the fish was in rapid movement. The expanded polyps may be seen on the gorgonian just above the fish and elsewhere. The lower picture shows a group of parrot fishes, of at least three species, and several surgeons against a background of branching gorgonians on a ledge of rock. Near the center is a blue and yellow-striped grunt, *Hæmulon flavolineatum*. At the left of this is a blue parrot-fish, *Callyodon cœruleus*. At the right of the grunt is a green parrot-fish, *Callyodon vetula*, about eighteen inches long. Beneath the green parrot is a mottled parrot-fish (*Sparisoma?*). Above the grunt is a second mottled parrot and to the left of this a third. At the extreme left are two surgeons, *Hepatus hepatus;* a third is seen below the green parrot. Above the green parrot, in the background, is a purple sea fan, *Rhipidoglossa*. In most of the fish the details of the markings and the outlines of the scales are clearly shown in the original photographs.

Subaquatic photographs such as these show a lack of distinctness which appears to be due to the turbidity of even the clearest water and to reflected light. But, as Professor Reighard points out, the lack of distance and flatness of the objects are truthful representations of the conditions that actually obtain. From the artistic point of view, they can not be regarded, therefore, as defects, though from the scientific point of view they place limitations on subaquatic photography.

SCIENTIFIC ITEMS

We record with regret the death of M. Antoine Henri Becquerel, the eminent French physicist, and of Dr. Friedrich Paulsen, professor of philosophy at Berlin.

Professor C. O. Whitman, head of the department of zoology in the University of Chicago, has resigned the directorship of the Marine Biological Laboratory, Woods Hole, Mass., which he has held for the past twenty years. Professor Frank R. Lillie, of the University of Chicago, the assistant director, has been elected to the directorship.—Mr. F. J. Seaver, assistant botanist of the North Dakota Agricultural College, has been appointed director of laboratories in the New York Botanical Garden.—Professor Rufus I. Cole, of the Johns Hopkins University, has accepted the directorship of the Research Hospital of the Rockefeller Institute of New York City.

By the will of the late Senator William F. Villas the University of Wisconsin will ultimately receive his entire estate, valued at between two and three million dollars. By the provisions of the will, Mrs. Villas receives the income during her lifetime, and after her death her daughter receives $30,000 a year. After the property is given to the university, part of the income will be reserved until the principal becomes $30,000,000. The will provides for the erection of a Henry Villas Theater, and for the establishment of ten professorships, each with a salary of not less than $8,000, nor more than $10,000 a year. —By the will of Frederick Cooper Hewitt, Yale University receives $500,000; the New York Post-graduate School and Hospital $2,000,000, and the Metropolitan Museum of Art $1,500,000 and the residue of the estate. —An anonymous gift of $100,000 has been made to the Vienna Academy of Sciences for the establishment of a "Radium Institute" in connection with the new physical laboratories of the University of Vienna.

THE
POPULAR SCIENCE
MONTHLY.

NOVEMBER, 1908

DEDUCTIONS FROM THE RECORDS OF RUNNING IN THE LAST OLYMPIAD

By Professor A. E. KENNELLY
HARVARD UNIVERSITY

IT is much to be regretted that after all the races held in the ancient days of Greece and Rome, when the laurel crown of victory was the height of ambition in youthful manhood, we have no means of comparing the achievements of their runners with our own. We shall never know how their track speeds compare with those of modern times, because records did not become possible until after the invention and development of the portable chronometer.

The olympiads, or quadrennial athletic meetings of ancient Greece, were held in such national renown, that they served as historical epochs for the chronological establishment of events. Owing, however, to the absence of sufficiently precise instruments for measuring and recording time, each race or speed-contest, although an event of great momentary importance, was necessarily cut off from all comparison with similar preceding or succeeding races. The victor in each race overcame the opponents who contested with him shoulder to shoulder; but there could be no means of determining whether the victor of a given event in one olympiad excelled the victor in other olympiads.

With the introduction of the stop-watch, races ceased to be merely momentary efforts for mastery in speed. To the interest of the local and passing contest was added the new interest of the perennial contest, and of the record. In the racing of the finest horses, the record has come to be regarded as the principal event, and the winning of the race as the secondary event, after the excitement of the occasion has subsided. In the racing of the swiftest men, the record is gaining in importance; but we still attach principal attention to the winning of the race, as did our predecessors in ante-chronometer days. Medals are given for races won and not for records beaten.

It is, perhaps, our attachment to the interest of the momentary race, and our ordinary indifference to the record, that accounts for the absence of enquiry into the laws of racing speeds. If we ask either an athlete, or a non-athlete who is athletically informed, what is the relation of a runner's speed over a long course to that over a short course, he will immediately reply that a racer over a short course, like 100 meters, runs at a higher speed than over a long course, like 3 kilometers. But if he is pressed for an estimate as to how much faster the racer runs as the course is shortened, he will either be likely to express indifference, or to intimate the opinion that a precise answer is impossible. Nevertheless, it is self-evident that the long list of records which have been established up to this date for runners on courses varying from 20 yards up to more than 600 miles, determine the average speed which the makers of those records severally adopted.

The records reported in the *New York Times* as having been made by the winners of the flat races in the London Olympiad last July are collected in the following table:

Length of Course. Meters	Winner's Actual Time. Seconds	Average Speed over Course Meters per Second	Winners	Time Estimated according to the Logarithmic Straight Line. Secs.	Discrepancy. Seconds	Percentage Discrepancy
100	10.8	9.26	Walker	10.45	—0.35	—3.2
200	22.4	8.93	Kerr	22.8	+0.4	+1.8
400	48.4	8.26	[1]	49.7	+1.3	+2.7
800	112.8	7.09	Sheppard	108.4	—4.4	—3.9
1,500	243.4	6.16	Sheppard	220.0	—23.4	—9.6
42,190	10,518	4.01	Hayes	9,390	—1 128	—10.7

In the accompanying illustration, these records are plotted on a specially ruled paper known to engineers as "logarithm-paper" or "log-paper," in which equal multiples scale equal distances, both vertically and horizontally. The horizontal scale represents course-distances in meters. The vertical scale represents running times in seconds. The stars near the numerals 1, 2, 4, 8, 15 and 420, locate the Olympian records for 100, 200, 400, 800, 1,500 and 42,190 meters, respectively, according to the table already considered. The various circular dots indicate world's records for running, taking the best from professional and amateur lists published in the New York "World" Almanac. The straight line is drawn through the record for 500 yards (457 meters), and also through the record for 7½ miles (12,070 meters).

[1] This contest was reported "no race" in the *New York Times* of July 24. The time, however, is here taken as that of the best preceding trial heat, won by Haswelle.

This straight line offers a simple approximate quantitative relation between record times and distances in races from 100 meters to 50,000 meters.

Considering first the black dots, or world's records, independently of the Olympic records, it will be seen that between 100 and 400 meters most of the records fall slightly below the straight line. This means that within that range the record times are shorter, or the speeds

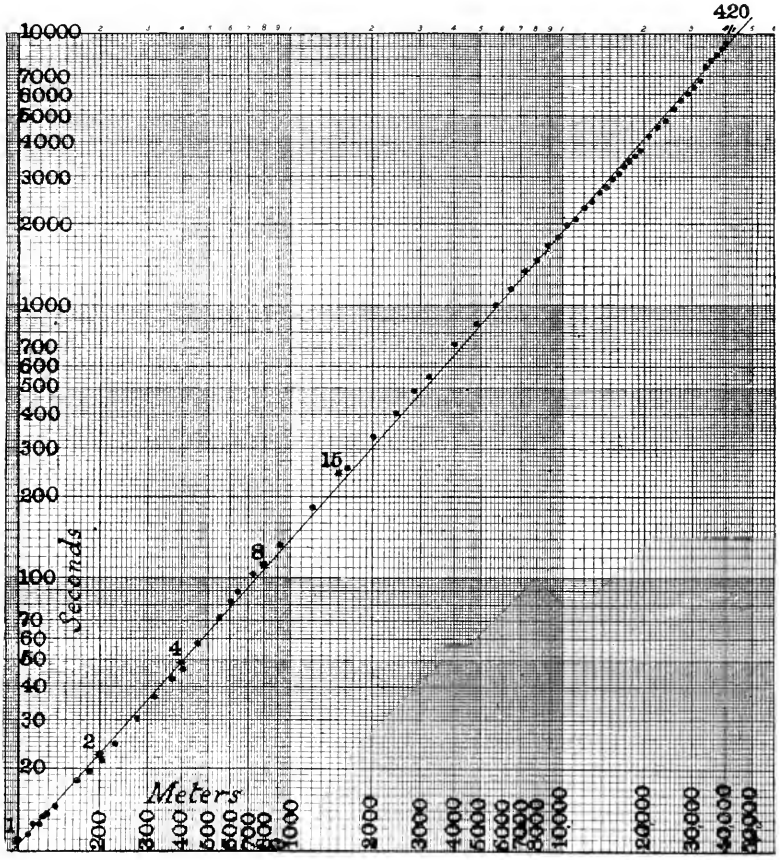


Diagram showing World's Records and Olympic Records in Running Races.

somewhat higher, than those represented by the line. Then, from 500 to 5,000 meters, the dots fall above the line. That is, the times are longer, or speeds somewhat lower, than those prescribed by the line within this range. From 5,000 to 12,000 meters, the agreement between the dots and the line is close. Between 12,000 meters and 32,000 meters, the dots again fall below the line; while beyond 32,000 meters, they change sides and rise above it.

Turning now to the Olympic records, we may notice that the 200- and 400-meter stars lie close to the line; but slightly above the nearest corresponding world's records. None of the Olympic record stars lie below the corresponding world's records; but the 100- and 800-meter stars lie close to the corresponding dots. The farthest away from the line is the 42,190-meter star. It is to be remembered, however, that the Marathon race is run over country roads, up hill and down dale; whereas all the other races are run on a smooth and level track. This circumstance may account for all, and must at least account for part, of the fact that the Marathon record is 10.7 per cent., or 1,128 seconds, behind the time set by the straight line. As for the smaller discrepancies in the other Olympic records, it is to be remembered that the contestants in Olympic games are amateurs, whereas the world's records are the best that professional as well as amateur champions have been able to secure in all racing annals up to date.

So far as appears on its face, the illustration suggests that the existing world's records offer a better chance of being lowered between 500 and 5,000 meters, than those below 500 meters, or those between 5,000 and 12,000 meters. It is, in fact, generally conceded that races up to the quarter mile (400 meters), inclusive, are the most strenuous, and that races of from half a mile to three miles usually leave the runners in a less completely exhausted condition. If this concession be denied, and we take it for granted that all these records from 100 meters to 50,000 meters call for like strenuousness of sustained effort and degree of physical exhaustion from equally good athletes, it is hard to explain the oscillations of the record dots in groups from one side of the straight line to the other.

The straight line in the illustration stands, however, for much more than a mere indication of possibilities in regard to records. It also involves the conclusion that any record-making runner becomes exhausted very rapidly as his average speed is increased. For example, in the above table of Olympic records, it appears that the athlete Sheppard held an average speed of 7.09 meters-per-second over the 800-meter course; but only 6.16 meters-per-second over the 1,500-meter course. We may safely assume that Sheppard arrived in each case at the winning post, "run out" or practically exhausted in running power; because if he had arrived with any residual running energy, he would have thrown it into acceleration on the last lap. Consequently, when he ran at 6.16 meters-per-second he ran himself out in 243.4 seconds; but when he increased his average speed, to 7.09 meters-per-second, he ran himself out in 112.8 seconds, or in less than half the time. That is, increasing his average speed 15 per cent. exhausted him in 46.3 per cent. of the time. The law of the straight line in the illustration is, in fact, that the time of exhaustion is inversely as the ninth power of the speed within the limits of racing speeds; so that a record-maker, if he were able to double his speed, would become exhausted 512 times more quickly. Of course, the straight line can only be regarded as an approximation to the actual conditions, and we are not justified in asserting that the law of the inverse ninth power applies strictly. The exhaustion time as the inverse ninth power of the average speed is an average law, derived from the world's records, as made by a number of different individuals at different times. It is, however, certain that whether the time of exhaustion for any particular racer is as the inverse ninth, eighth or other power of his speed, it is a relatively high inverse power. We may safely conclude from the records that a record-making runner can not increase his speed within racing limits without bringing down his time of exhaustion very rapidly. Otherwise, the record times over different lengths of course would surely follow a different series.

It further follows from this deduction that a record-making runner can not afford to run at an unduly high speed for any appreciable time during his race; because, if he were to do so, he would thereby exhaust himself at a yet more unduly great rate. It would seem that in order to make his best time he must keep to a uniform pace, at least to a first approximation. It is evident that on the last lap he will put forth all his remaining effort, and spurt if he can; because he should arrive at the goal run out if he has done his utmost. If, however, he is able to spurt to a marked extent on his last lap, he has held too much energy in reserve, which he consumes unduly rapidly at the higher speed. According to the logic here set forth, he should have been able to reach the goal more quickly by a slight uniform increase in speed over the whole course.

According, then, to the deductions that the straight line of the illustration leads up to, an athlete of record-making quality should be enabled to make his best time over his best course or courses, by being paced at a uniform rate, say with an automobile. This, however, assumes that the runner would exert himself as fully behind an automobile as when running shoulder to shoulder with an antagonist. This is, perhaps, treating an athlete like a mere automaton, instead of like a human being. It seems more reasonable to suppose that an athlete's best performance can only be elicited under the spur and incentive of individual competition. Besides, the interest of a race to the onlookers would probably be greatly diminished if instead of the struggle of a number of racers were substituted the effort of a racer to keep up with a motor.

Nevertheless, the opposite proposition will be likely to meet with general approval; namely, that the worst way to elicit a good performance from a record-making type of runner is to incite him to an unduly high speed at some part of the course before the end. The average speed of a record-making Olympic runner on a 100-meter course is given in the table as 9.26 meters per second. In the 1,500-meter race, Sheppard averaged, as we have already seen, 6.16 meters-per-second. Suppose that he commenced, say, by running at 9.26 meters-per-second. This would have been only 50 per cent. more than his average speed. It is clear that, had he done so, he would have been run out in 10 seconds. Again, if he had commenced by running at 7.09 meters-per-second, his average speed over the 800-meter course, and not quite 15 per cent. above his average speed over the 1,500-meter course, he would have been run out after 112.8 seconds, or only about half way.

It seems possible, however, to combine the incentive of shoulder-to-shoulder competition with uniform pace-making, and without loss of interest to the spectators, by running a light flag or pennant by the side of the track, on a slender wire of steel or phosphor-bronze. It would only be necessary to set short posts beside the track, each supporting a light metallic guide-pulley. Over all these pulleys would run the wire alongside the track, making a complete loop or endless chain. The wire would be propelled at some point in the course by a small electric motor, driven by a portable storage battery, as in the outfit of an electric automobile. An attendant at the motor would be charged with the duty of keeping the speed of the motor and wire uniform at that corresponding to the record for the particular event. By means of a *stroboscopic fork*, *i. e.*, a tuning-fork carrying slotted wings on its prongs, through which a rotating target carried by the motor appears to stand still, it is readily possible to keep the speed of such a motor and wire constant to within a small fraction of one per cent.

When the runners were placed and ready to start, a small flag would be gripped on the running wire a few paces behind the men. As this flag reached the starting line, the starter would fire his pistol. Owing to the starting inertia of the men, the flag would gain a few feet at the first, and the runners would get under way with the flag slightly ahead. Since the flag would reach the winning post in record time, it would be the object of the men to outdistance it at that point. According to the reasoning above presented, they should best be able to do this by keeping close to the flag, which would serve as pacemaker. They should certainly be advised thereby if they started off at too high a speed. The spectators would have the advantage of seeing not only the contest of the actual runners; but also a contest with the "ghost" of the best runner that heretofore had made the record of that event his own, as impersonated in the flag running beside the track.

In raising the ghost of the record runner as above, there might be a danger of hurting the race by the runners losing heart if they failed to keep up with the flag. There might also be a danger of the spectators' losing interest if the flag removed all temptation from the runners to jockey for first place, thus tending to sustain monotony at the expense of sport. Whether these dangers are serious could only be determined by actual trial.

It would, of course, be possible to reduce the speed of the flag, by preconcerted arrangement, to a more readily attainable local record, in place of a more ambitious world's record. One per cent. reduction in speed might make a very marked difference in this respect. There can be little doubt that the flag and motor-driven wire would be a useful device in the training of runners for the track at suitably graded speeds.

The same line of reasoning applies to other races. If the world's records in walking, swimming, skating, rowing, horse-running, horse-trotting and horse-pacing be similarly analyzed, and plotted on logarithm paper, the points will be found to fall very nearly upon a straight line in each case.[2] Moreover, all of the straight lines have the same, or at least substantially the same, inclination, or represent and involve substantially the same law of fatigue. The only exception is found in bicycle-riding.

[2] "An Approximate Law of Fatigue in the Speeds of Racing Animals," by A. E. Kennelly, *Proceedings of the American Academy of Arts and Sciences*, Vol. XLII., No. 15, December, 1906.

MONTE ALBAN AND MITLA AS THE TOURIST SEES THEM

By Professor CHARLES JOSEPH CHAMBERLAIN
THE UNIVERSITY OF CHICAGO

IN April, 1908, while investigating the Mexican cycads in the vicinity of Oaxaca, I took occasion to visit the ancient ruins on Monte Alban and at Mitla. A botanist could hardly be expected to speak with any authority upon archeological matters, but, having taken an excellent camera for photographing the cycads, I could not resist the temptation occasionally to point it at objects of mere human interest. Upon examining the photographs, a friend, who has made some reputation as an archeologist, suggested that an illustrated account, written from the standpoint of an ordinary tourist, would be of interest to the public, while the photographs might be useful to those better acquainted with the general subject.

Oaxaca is easily reached. Starting in the morning from Puebla over the Mexican Southern Railway, there is a pleasant ride of 228 miles through magnificent mountain scenery and prosperous plantations. From Tomellin to Las Sedas, forty miles, there is a grade so

Fig. 1. Some bear Pictorial Inscriptions.

FIG. 2. THE BIG TREE OF TULE.

steep that I was told one could coast all the way from Las Sedas to Tomellin. On the trip back I tried it and found it to be delightfully true. On a small square platform, resting upon two pairs of freight car wheels, the trip was like a long, breezy shoot the chutes, the speed sometimes reaching more than thirty miles an hour. The precipitous cliffs, lofty mountains and deep gorges, together with gigantic cacti, are some of the sights of the Republic.

The station stops of greatest interest are Tehuacan and Tomellin. Tehuacan is beginning to be called the Carlsbad of the New World, for its wonderful mineral waters are producing cures which rival those of some of the famous Mexican shrines. The water certainly has a pleasant taste to recommend it and throughout Mexico one constantly meets people who have been cured of various kinds of kidney, liver and stomach troubles. At Tomellin, the Chinaman, Dick-Kee, who con-

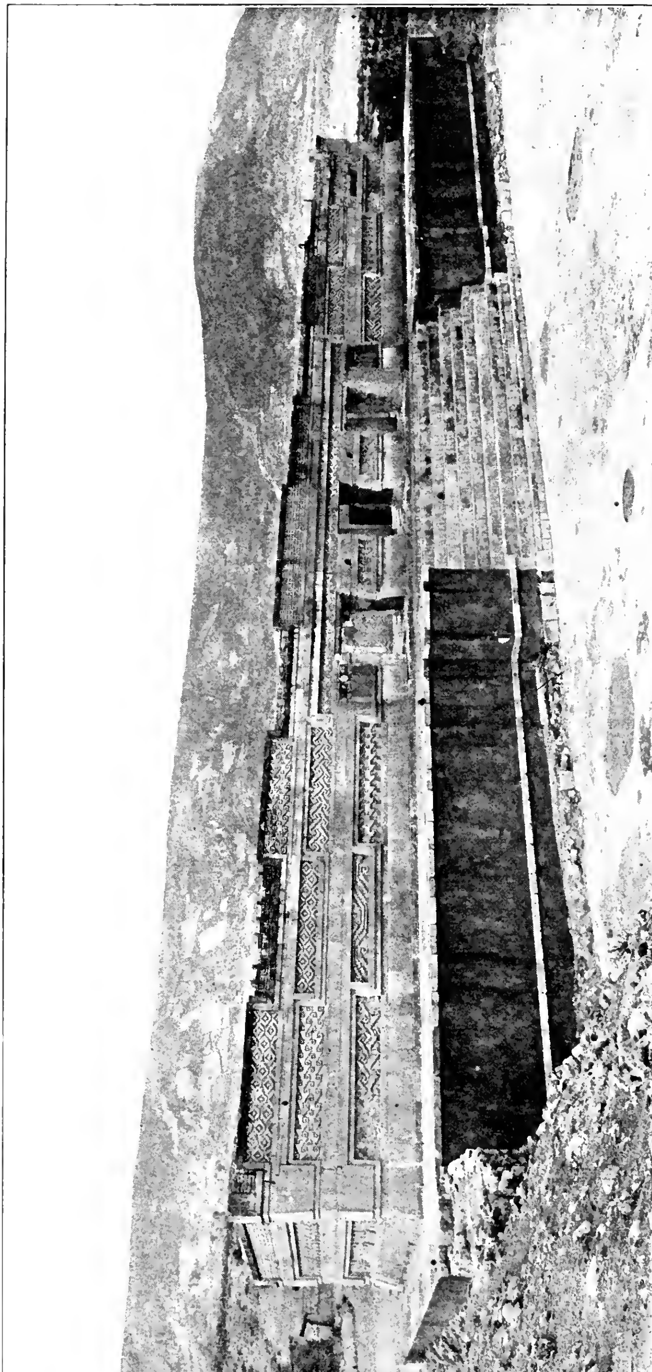


Fig. 3. A Building facing a Large Court.

ducts the railroad restaurant, makes you wish that you could stop for hours instead of only twenty minutes. On the way back, I had the pleasure of stopping at Tomellin and eating at my leisure, while I watched my less fortunate neighbors trying to eat three kinds of meat, with side dishes, pie, cake and ice cream in the regulation time.

Oaxaca, at an altitude of 5,000 feet, has a climate like a perpetual Indian summer. Already a prosperous town in the time of Columbus, it has grown until it has become an important commercial center, and

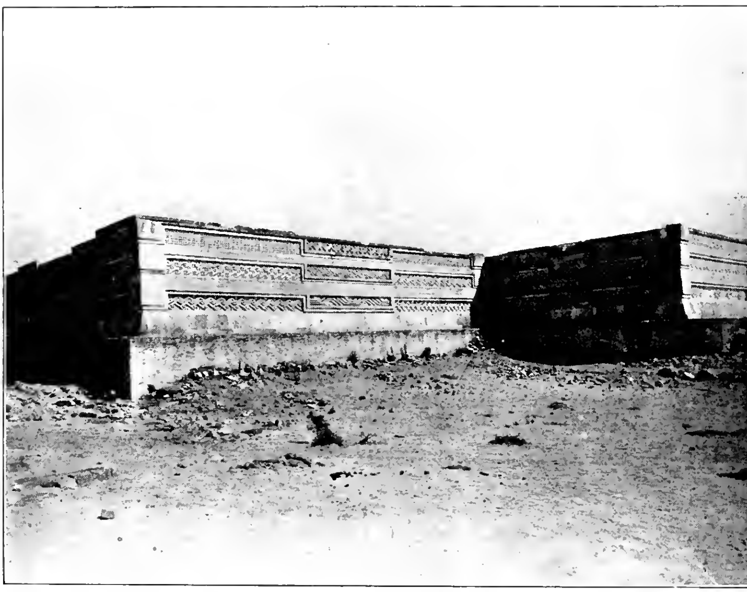


FIG. 4. ONE CAN HARDLY REALIZE THAT HE IS GAZING UPON RUINS.

its numerous cathedrals with their paintings and gorgeous decorations have made it interesting to the artist and architect. The hotels are good and the obliging hosts are always ready to arrange trips to Monte Alban and Mitla.

Monte Alban is said to be about four miles from Oaxaca. It seems farther if you go on foot. The average tourist, even though a bad rider, had better get a horse. When the top is reached, more than a thousand feet above the city, the view of the valley, with Oaxaca spread out like a map, the little villages, rich plantations, and Tule in the distance, is well worth even the climb on foot. The summit of the mountain is covered by the ruin of an ancient city. Whether the individual buildings are temples, stores or palaces, the tourist can doubtless decide with far less hesitation than can the trained archeologist. Some of the stones are large and well cut, some, like Fig. 1, bear pictorial inscriptions, and some have outline images of the entire

Fig. 5. A Court with Buildings arranged about it.

human figure, which to the novice look like Egyptian or Assyrian work. There are pyramids with rude passages leading through them and also chambers, perhaps basements of larger buildings with entrances of primitive construction. There are no arches anywhere. Floors, which in most cases are of a hard cement, resembling modern Portland cement, are still in a good state of preservation. Considering the fact that it is only recently that these ruins have been uncovered, it is not at all improbable that neighboring mountains may also have their ruins of temples and palaces.

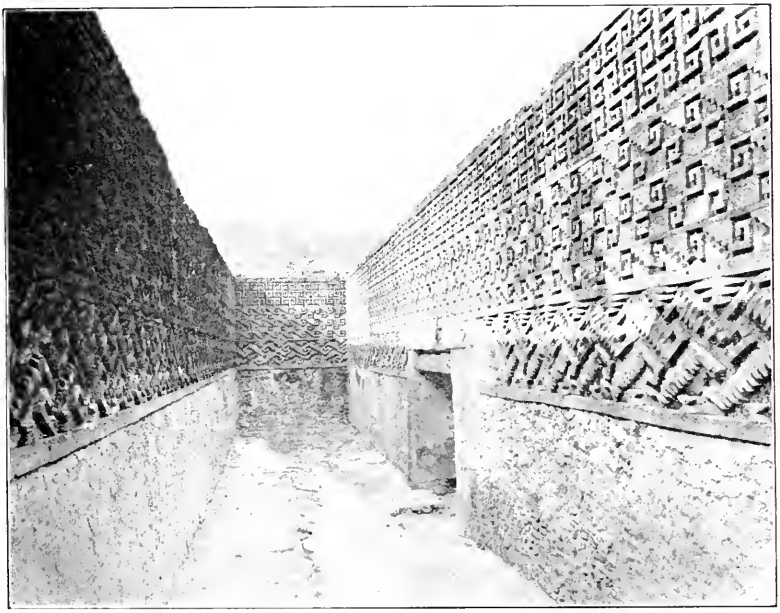


Fig. 6. Hall of Mosaics.

There is nothing to eat or drink on Monte Alban; consequently those to whom twelve o'clock brings a restlessness which scenery and ruins can not relieve had better carry a lunch.

A trip to Mitla can be arranged any day. The six-horse coach with four horses abreast in front and two horses in the rear, is the usual means of transportation. Such a coach, which will carry four persons, can be hired for two days for $18 to $25 Mexican money.

About an hour's ride from Oaxaca is the little village of Tule. Even the ordinary tourist must stop here to see the big tree in the churchyard (Fig. 2), but the botanist should leave Oaxaca early by the little tram car and study the tree an hour before the rest of his party arrive. The tree is gigantic, measuring 154 feet in circumference six feet from the ground. This means more than 50 feet in diameter, thus

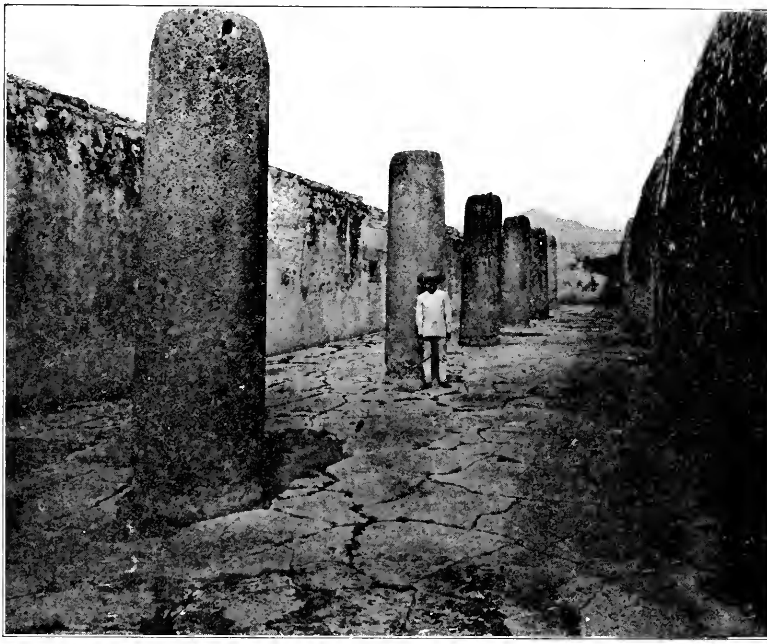


FIG. 7. HALL OF MONOLITHS.

surpassing the big sequoias of California. The height, however, as may be seen from the picture, is not so great. Botanically, the tree is *Taxodium mucronatum*, and it is commonly called the Montezuma cypress. The *Noche triste* tree in the City of Mexico belongs to the same species. The swamp cypress of our southern states, *Taxodium distichum*, belongs to the same genus, but not to the same species. Without trying to find any fault with the tree, one might hazard the suggestion that it may represent three trees grown together so that nothing but peculiarities in the branching remain to indicate a multiple origin. The Humboldt inscription, placed there by the great explorer, is on the opposite side of the tree from that shown in the picture, but is now almost entirely overgrown. There have evidently been other inscriptions, but they too are overgrown, and a formidable tablet warns the public against defacing the tree, perhaps referring to the vicious American habit of cutting unimportant names in conspicuous places. There are recent tablets, flat on the ground at the base of the tree, with large letters made of the teeth of cattle. If it is all one tree, its age could not be less than three or four thousand years. In the same churchyard there is another Montezuma cypress, twelve feet in diameter, which shows not only in its general habit, but in its branching, that it is a single tree.

The road from Tule to Mitla is sandy and dusty, but the scenery makes one forget such trifles. The mountains on the right are rocky and are covered with yellow and green lichens. Those on the left have some trees and the valley between is fertile, and the people—as everywhere in Mexico—are happy and contented. Not to be forgotten are a couple of little villages where one can get pineapple cider and lemon ices.

Arriving at Mitla about noon, one is surprised at the comfortable hotel with neat, airy rooms, clean beds and excellent fare. Even a fastidious fault-finder could live there and worry because he could find nothing to criticize.

After luncheon, a five minutes' walk brings us to the ruins. The crude remains on Monte Alban had prepared me for a disappointment at Mitla, but the first view removed any such anticipation. One can hardly realize that he is gazing upon ruins so old that no one knows their age or who built them. The reader will admit that Fig. 4 looks more like the finished work of an up-to-date architect than a ruin. This picture shows the general style of the exterior of all the Mitla ruins. Everywhere there is the same elaborate ornamentation.

The interior side of a building facing a large court is shown in Fig. 3. The stair has been partially restored, but otherwise the description made by Cortez applies equally well to-day. Through the entrances at the head of the stairs one catches glimpses of the rooms

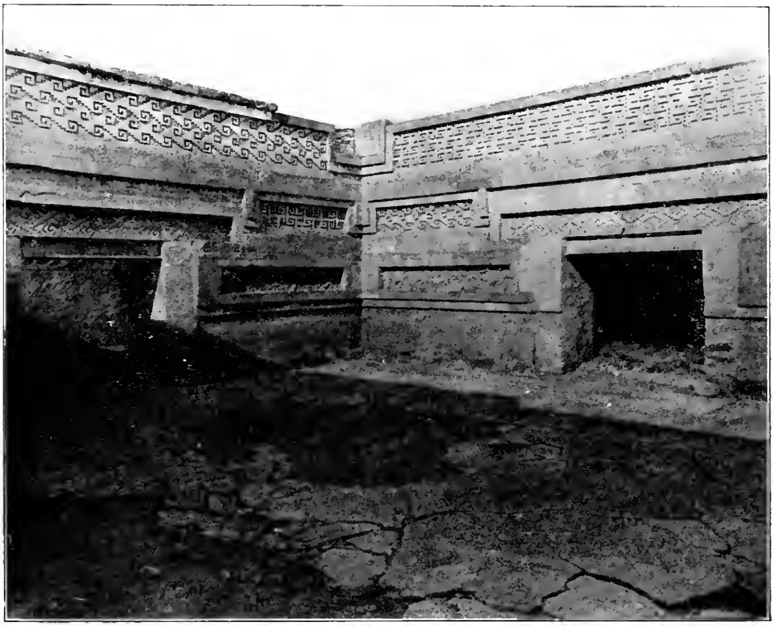


FIG. 8. A WELL-PRESERVED CORNER.

beyond. At present the rooms are not at all roofed over. On each side of the central entrance is a hole in the wall from which an idol has been removed. The court in front of the steps is of a concrete like that found on Monte Alban. Monoliths like the one in the foreground are fairly numerous. Another view of a court with buildings arranged about it is shown in Fig. 5.

The rooms of the buildings surrounding the courts are still very beautiful. Among these, the *Hall of Mosaics* (Fig. 6) seems to be the best preserved. If these long, narrow halls were ever covered by any heavy roof, the ventilation must have been bad, for even in their present open condition they are hot enough on a warm day.

FIG. 9. THE STONES ABOVE THE ENTRANCES ARE VERY LARGE.

Another hall, considerably wider and with a row of six huge monoliths in the center, is called the *Hall of the Monoliths* (Fig. 7). These monoliths, which are about twelve feet high, seem to have supported some kind of a roof, and, judging from their strength, the roof must have been something more than cloth or palm leaves. The walls have no mosaic ornamentation, but seem to have been completely covered by a hard, thin coat of cement or plaster, which was painted a dark red. Just beyond the second monolith one sees in the wall a niche which may have contained an idol.

A well-preserved corner is shown in the following view (Fig. 8). Since the masonry has begun to crack, steel beams have recently been

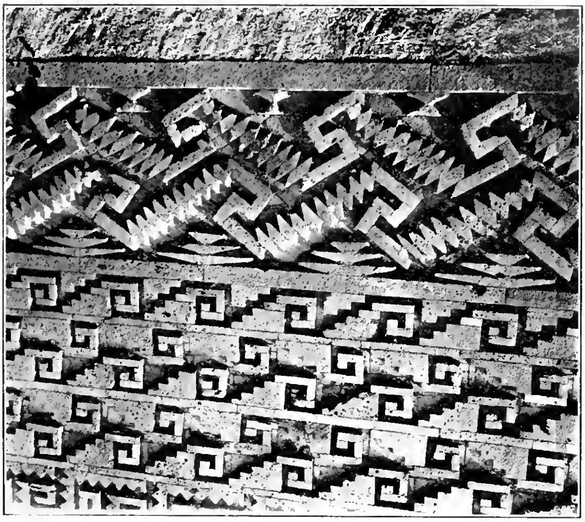


FIG. 10. DETAILS OF THE MOSAICS.

inserted above these two entrances. The rooms beyond the entrance are narrow and elaborately ornamented with a pattern similar to that in the Hall of Mosaics.

The stones above the entrances are very large. The one shown in Fig. 10 is eighteen feet long. The side of the entrance, against which the children are standing, is also a single stone.

The dark spot on the cement floor, seen through the opening, is the entrance to a series of subterranean chambers. These are low,

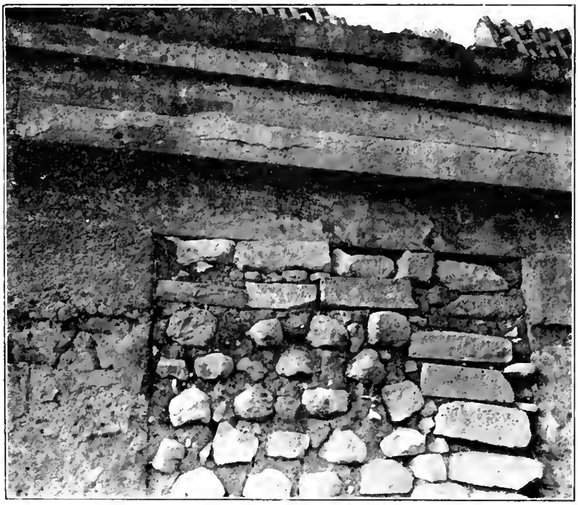


FIG. 11. PICTURE WRITING.

dark dungeons, ornamented with the mosaic patterns shown in previous views. A modern steel gate with a big lock keeps out unaccompanied travelers. After we enter, get candles and register our name and address, the guide conducts us from one room to another, sometimes coming up into rooms open above, but which we had not seen before, and then going down again until we get bewildered.

The details of the mosaics are interesting (Fig. 10). As is already seen from the picture, the design is partly cut and partly laid. The pattern projects about two inches and in the lower part is very peculiar in its angles and in the regularity of its irregularity. The entire structure, even the smallest pieces, is of stone, there being no bricks in the construction. Not only the mosaics, but all other parts of the buildings are put together without any mortar or cement. The fitting is extremely accurate and the edges of the stones, in many cases, are as sharp as if recently cut. The stone is like that found everywhere in the neighboring mountains.

Aside from the mosaics, the ornamentation has largely disappeared. The guide informed us that even within his memory there had been large patches of picture writing like that shown in Fig. 11, but that enterprising tourists had chipped off so much of it that the entrances to the chambers had been walled up as in this picture, so that they are now reached only when the steel gate is unlocked by the guide. By looking closely just above the walled portion, one can see the general character of this ornamentation. The groundwork is a hard plaster painted a dark red, while the tracing is in white.

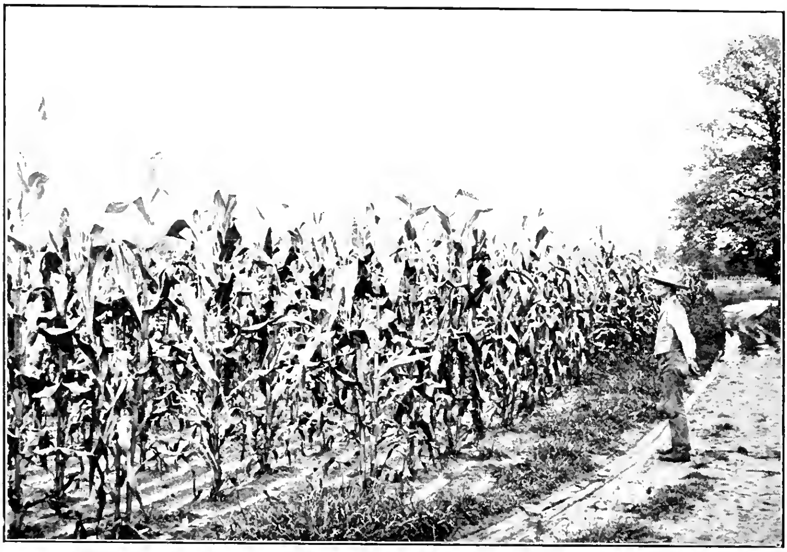
What the buildings were for is a problem which the tourist is more ready to solve than those who are better informed. Perhaps these are the ruins of a great temple. To one tourist, at least, they seem to have been better adapted to the festivities of a great royal court. But whatever they may have been for, they prove that the people who built them were well advanced in art and architecture.

THE ROTATION OF CROPS

By SAMUEL FRASER
GENESEO, N. Y.

THE rotation of crops or the order in which crops are grown upon the same land during a period of years is of such moment to the successful development of our agriculture, and consequently of our national welfare that it must receive consideration. The farm value of our farm products has increased rapidly in the last few years, having risen from $4,717,000,000 in 1899 to $7,412,000,000 in 1907. The figures indicate an increase in value for 1907 of 50 per cent. over 1899. This remarkable growth in the value of farm products is largely due to an increase in the area tilled. Now that the best land is settled, it is essential to increase the productivity of an acre, and as the rotation of crops is one means of securing this result its usage must extend. The use of manure and fertilizers have been recommended and proved to be of value in the eastern states for increasing crop yields. The value of plant breeding and the development of plants which are capable of giving heavier yields and products of better quality has been recognized; and the productions of many workers have added millions of dollars annually to our national welfare. It is safe to say that anything that benefits the farmer and increases his ability to produce wealth is of distinct value to the nation and of direct interest to the world.

A study of the rotation of crops used at any particular period in the history of a nation is of value as a guide to the status of agriculture. Agriculture had its birth in the ages of antiquity, when some mother conceived the idea that she might save herself and her child from famine by growing or affording protection to some of the plants which furnished food. From this time on and for a long time the requirements of the people were scanty, and the crops grown were so few that no rotation could be carried on. Evidence shows that the neolithic people of Europe had the rudiments of agriculture, that they grew cereals, had cattle and were conversant with the arts of weaving, spinning and pottery-making. Among other places, they inhabited the hills of Britain and Ireland, where terraces made by them on the hill-sides in Wiltshire and even as far north as the Cheviot Hills and the Grampian Mountains of Scotland are still visible. These races practised irrigation and a system of agriculture something like that now in vogue on the hills of parts of China and among the Coorgs, a hill



It is a Four Course of (1) Corn, (2) Oats, (3) Wheat, (4) Hay—Timothy and Clover. First year. Corn, grown for silage. About 10 tons of silage is cut per acre. Corn permits of intertillage and cleaning the land of weeds.

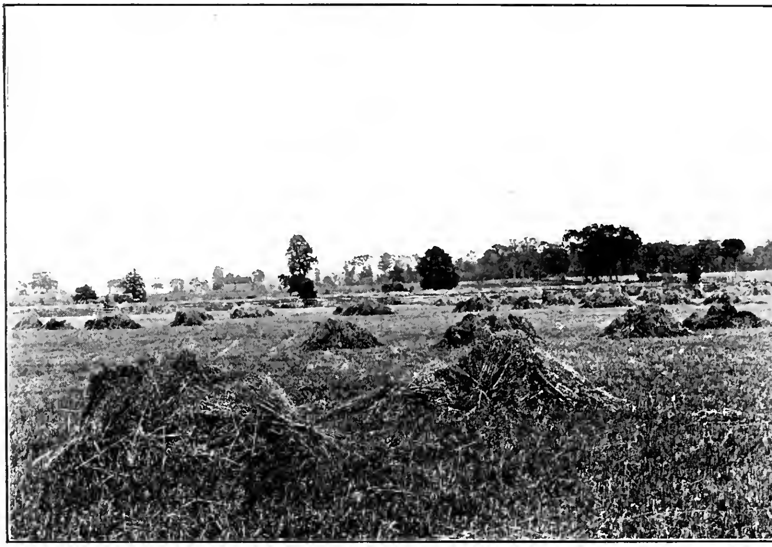
tribe, in India. The inhabitants of Britain were Iberians, a non-Aryan race and related to some of the hill tribes of India. The hills were peopled first because they were free from trees, and the soil was easy to till, while the valleys were swampy, marshy and often covered with timber, which they had no means of removing except by fire. The forests were held to be more or less sacred, even at so late a period as the Roman invasion. The Druid priesthood is held to be of non-Aryan origin, but surviving a conquest, was accepted by the Celts. Two Aryan races, the Celts and the Saxons, invaded Britain, one before and one after the time of the Romans and both learned their agriculture from the race they overcame. At this time the community generally owned the land, and its management was vested in officials elected for the purpose. The Romans introduced individual ownership, and this was never uprooted. It grew gradually under the Saxons and more quickly under the Normans, but made its most rapid progress during the fifteenth and sixteenth centuries, when wool was the valuable product and land was wanted for grazing sheep. During this time the customary method was to cultivate a piece of land for a few years and then, leaving it to go back to grass, break up another piece, and cultivate it until it became unprofitable. It is interesting to note that wherever population is scanty this method is adopted, whether in the ages of antiquity in Europe or during the nineteenth century in America. In some parts of the United Kingdom, modifications of this system existed at a comparatively recent date. The

FIRST YEAR. CORN. Whenever possible part of the crop is grown to furnish corn and the storer (stalks and leaves) are fed to steers and young cattle. The present high price of grain is forcing the farmers to grow more concentrated feeds on their farms.

town of Kells, in Ireland, owns 1,700 acres, which was farmed by the community. About 130 acres were broken up at a time, and were cropped for four years with wheat, beans and fallowed and then seeded to grass and another 130 acres were plowed. Stock was grazed on the untilled land, each citizen having the right to put a certain number of stock on the common. The town of Lauder, in Berwickshire, Scotland, had a similar custom. These examples illustrate some of the methods in use when the Pilgrim Fathers sailed for America, and the rotation of wheat, beans and then a fallow remained the most common in Britain until 150 years ago.

Xenophon speaks of a two years' cropping of wheat and fallow, and Roman writers remarked on the value of growing a leguminous crop before sowing wheat, a fact which remained almost unused until 150 years ago and unexplainable until the close of the last century. Now it is a maxim that at least one leguminous crop shall be grown in a rotation, because such crops have the power of gathering nitrogen from the air in the soil, and their roots and stubble when plowed under enrich the soil in humus to a greater extent than most other crops.

In the early days of this country and in newly-occupied places it was customary to grow one crop, either wheat, corn, tobacco or cotton, as circumstances required, for a number of years upon the same land, until the yield from the crop was reduced to such a point that it became unprofitable. More land was then taken and treated in a similar



SECOND YEAR. GRAIN CROP—OATS. On the Cornell University Farm yields of 50 bushels per acre are often secured.

manner. Such methods are permissible only in a thinly populated country. Some time previous to this some men had noted that in nature the crops grown on a piece of land during a term of years varied, and it is common observation to-day that in the north, hardwood trees, as oaks, will come in where pines have been cut off. Hemlocks do not succeed hemlocks. And even in grass land marked changes occur in the composition of the herbage. During a period of wet years Redtop (*Agrostis vulgaris*) may assume the ascendancy on a piece of land, and lose it just as quickly when an era of dry years occurs. To secure a rotation of crops, it is essential that crops capable of being grown in a district be known and that there be a market for them. Wheat has been and is the pioneer crop of the northwestern parts of this continent. Climatic conditions are important factors in determining the rotation. In Canada, oats, mangels, clover and timothy may be good crops to include, but they would be of little value for the southern states. Cotton, cowpeas and crab grass would be more likely to grow. It was largely lack of knowledge about crops that prevented progress. Clover and turnips were not grown as field crops in England until about 170 years ago, and even about a hundred years ago, Arthur Young said that probably not more than half the farmers and certainly not over two thirds grew clover, although both turnips and clover were recognized as of value in the sixteenth century, and turnips were used as an article of diet at least as early as 1390. About 1730 Lord Townsend introduced on to his barren estate in Norfolk what has

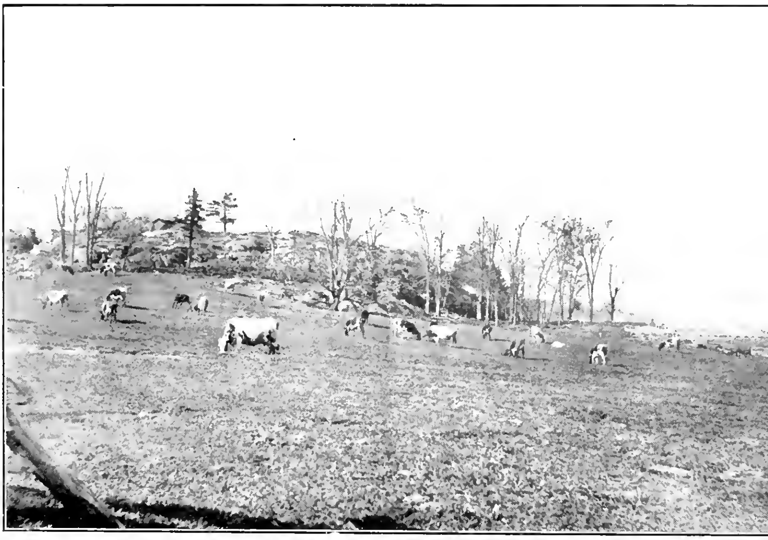
THIRD YEAR. WHEAT. PREPARING LAND FOR WHEAT. The last harrowing is being given. A fine tilth has been obtained as evidenced by the cloud of dust which obscures the horses' feet, the harrow and the man. Certain crops permit the disintegration of the soil particles by tillage.

since become known as the Norfolk four-course rotation, consisting of turnips, barley, clover, wheat, and yet, in spite of the most gratifying results, it took seventy years of demonstration before this system of rotation spread over the county of Norfolk. Dickson, of Edinburgh, Scotland, wrote a treatise on the rotation of crops in 1777 and in 1788 Marshall, of England, stated that a common rotation was: first year, wheat, barley or bigg; second year, oats, beans or pulse; third year, fallow. Although the value of a rotation of crops was known to Camillo Tarello, who urged the adoption of such a system in agriculture in 1566, before the senate of Venice, it was little understood elsewhere. Tarello was far in advance of his time and gave a list of the advantages of a rotation, somewhat similar to those known to-day. Yet his careful experiments remained unknown and little used until similar facts were discovered elsewhere. In Great Britain, previous to the translation of Tarello's article and the issue of other works during the eighteenth century, the subject of rotation was generally passed over by reciting courses which might be good, bad or execrable, as though their arrangement were devoid of principle and had absolutely no relationship with the economical management of a farm. That poverty in an agricultural community might be due to a poor rotation of crops and success due to a good one never occurred to the minds of those who ought to have been interested. The value of carrying live stock to consume part of the crops grown had not been recognized, and

FOURTH YEAR. HAY—TIMOTHY AND CLOVER. In 1903 the grass field was mown twice and yielded $5\frac{1}{3}$ tons of hay per acre in two cuttings. In 1904 one field yielded $4\frac{1}{2}$ tons per acre, the first cutting.

the truth of the proverb—"No grass, no cattle; no cattle, no manure; no manure, no crops"—had not been appreciated. Townsend's four course considered something more than supplying man with grain, a new point of view arose, and in regard to it Arthur Young said: "The grand article of all husbandry is the keeping great stocks of cattle; for without much cattle, there can not be much manure." Two out of the four crops, clover and turnips, and the straw from the grain crops were used for the live stock, either as food or as bedding and the result was a large supply of manure and increased productivity of the soil. The grain crops were separated either by an intertilled crop, turnips, or by a legume, clover. Substituting corn for turnips we have a rotation of equal value for the northern states.

The introduction of clover and turnips into England as field crops is coincident with the improvement of live stock by Bakewell. From this time on meat was added to the diet of the common people of Britain, in small but increasing quantities. It is worth noting the effect that the call for meat had upon the minds of the thinkers of two divisions of the Teutonic race. The English school—including Bakewell, Coke of Holkham, Booth, Bates and many others—set to work to so improve the conformation of their breeds of live stock that they should be capable of producing a pound of beef, mutton or milk more economically; while the German school, led by von Thaer, began the epoch-making research as to the influence of foods upon their live stock, their efforts being to make the foods produce meat more econom-



LIVESTOCK IS A NECESSITY ON A SELF-SUSTAINING FARM. Frequently the four-course rotation used on the Cornell University Farm could be profitably made into a five-course, by retaining the grass for two years, making hay the first year and pasturing it the second.

ically. Thus the one school improved the animals, but paid less attention to the foods, while the other made the ration the primary consideration. Lancaster County, Pa., has made history both for its productivity and its rotation of crops. The two are inseparably connected. Corn, oats, wheat and clover and timothy are grown in the above mentioned order, and the farmers of this vicinity, realizing the value of manure, have purchased western live stock and corn and with the roughage grown have fattened the stock and made money. The object of a rotation should be to convert sunshine into dollars, in such a manner that the soil used shall be as productive at the end thereof, if not more so, than it was at the beginning.

Wheat or corn growing employs a minimum amount of help for short definite portions of the year. Mixed farming, where live stock is kept, requires the retention of help throughout the year, and in this way it is of social importance, a floating population being a serious menace to a nation.

Where the one crop, as wheat, is grown, there is much more trouble in maintaining the soil in good physical texture. When clover is grown, the stubble and roots plowed under increase the amount of organic matter in the soil, which upon decaying forms humus. Humus aids in developing bacterial activities in the soil, the importance of which is now recognized, although feebly understood. The strong taproots of such plants as clover or alfalfa upon decaying leave air passages in the soil and subsoil, which are of great value in aeration, and render the soil more habitable for certain useful bacteria and more permeable to moisture and roots of succeeding crops.

Constant tillage of most soils may make the particles so small that they tend to run together in wet weather and bake into a hard mass upon drying. Putting land into grass for a few years permits the aggregation of soil particles and in this way a rotation corrects injuries.

Fields in grass are less expensive to work than the same area under intertilled crops as potatoes, or roots, hence a mixed farm can be managed well on less capital than one entirely under tillage. If grass can not be grown, alfalfa may be. Alfalfa is usually left undisturbed for several years and like other legumes produces marked increases in the succeeding crops. At Rothamsted Experiment Station, England, land which has been growing leguminous crops for fifty years was plowed up in 1898 and sown to wheat for the five following years with the result that the average annual yield per acre for this period was 27 bushels on the alfalfa plat, 24 bushels after white clover, 23 after red clover and sainfoin, 22 after sweet clover and 20 after peas, beans or vetches, while on the plats growing wheat and fallowed on alternate years for the same length of time, the yields averaged 7.5 bushels per acre per annum during the five years under consideration.

Grain crops as commonly grown do not permit of intertillage, hence the land is liable to become weedy. Intertilled crops can not be successively and profitably grown for a series of years unless they are specialties and bring high prices, as truck crops near towns. Under these circumstances special care is taken in manuring and fertilizing and in combatting insects and diseases. Constant intertillage depletes the soil of its organic matter, the trucker puts this back in his manure. At the Cornell University farm, which is run as a dairy farm, the four-course rotation of (1) corn (land manured about 8 to 10 tons per acre) cut for silage, (2) oats, (3) wheat (manured 8 to 10 tons per acre) and (4) clover, 10 pounds, and timothy, 15 pounds of seed (sown in the wheat), mown twice, has been quite valuable in bringing a poor unproductive farm into a high state of productivity. About 10 tons of corn silage is grown per acre, 50 bushels of oats, 30 to 40 bushels of wheat and over 5 tons of hay per acre (two cuttings). The root residues and the manures applied have been sufficient to preserve and augment the humus content of the soil.

Many plant diseases and insect attacks are easy to combat if a good rotation be adopted. These troubles have and will do more to enforce the consideration of a rotation of crops than almost any other factors. During the year 1904 in trials of mangels on the Cornell University farm the value of a rotation of crops was shown. Two plats separated by others had been growing mangels for three years. In 1903 the leaf spot disease (*Cercospora beticola*) was prevalent. In 1904 the crop was sown on these and on plats which had been in corn in 1903 and other crops previously. The disease attacked the beets on the "no rotation" plats early in the season, and many rows had to be resown. The yield per acre was 9.5 tons containing one ton of dry matter, value $20. The yield per acre on the rotation plats was 33½ tons containing four tons of dry matter, value $80, a clear gain of $60 per acre from the rotation of crops.

Different crops require different amounts of water to make a pound of dry matter, that is, some transpire more than others, thus oats will transpire 500 pounds, potatoes and corn about 300 pounds, barley about 400 and clover frequently over 600 pounds. From this it will be seen that the Maine farmer is wise because he is discounting the season, when he sows oats the year after potatoes in his rotation of clover (two years), potatoes, oats; thus a light water consumer is placed between two heavy consumers. This is important since water is generally the factor which controls the yield of crops. At Rothamsted, England, where wheat has been grown for 60 years on the same piece of land without manure or fertilizer, the average yield per acre is about 12½ bushels, while on land in a rotation—but otherwise similarly treated—the average yield was about 26 bushels. During the last 52 years the total yield of wheat is 665 bushels, which at 75 cents per pushel is worth $498.75. That of continuous barley growing, also without manure or fertilizer, during the same time, was 868 bushels worth $434 at 50 cents a bushel. When wheat and barley were grown in rotation with roots and clover or beans, without manure or fertilizers, the yields and values of the 13 crops of each were roots 9.5 tons, $19; barley 333 bushels, $166.50; clover (5 crops) 4.42 tons, $44.20; beans (8 crops) 104 bushels, $104; wheat, 335 bushels, $251.25; a total of $594.95.

The income from the land under this system is in favor of the rotation. It is $96.20 or 19 per cent. ahead of continuous wheat farming and $150.95 or 34.75 per cent. ahead of continuous barley farming.

Scientists have been kept busy explaining why we should get better yields from a rotation of crops. De Candolle over 100 years ago suggested that plants excreted a poisonous substance which rendered the soil objectionable to others of the same species, a theory which is again coming into some prominence. The continuous culture of wheat and barley at Rothamsted was undertaken partly to test this. Experiments now being conducted at Woburn Fruit Station, England, show that grass injures fruit trees, and it is claimed that the injury seems to be due to some poisonous substance, either direct or due to bacteria. Liebig suggested that plants tended to exhaust the soil by the removal of different ingredients and that as some plants took more of one ingredient than others, a rotation tended to strike a balance. The actual amount of plant food removed from the soil by crops is infinitesimal, and usually a good rotation will remove more than single cropping. The losses of valuable ingredients from the soil by wind or washing are of more importance than those lost by the sale of crops.

The practical benefits from a rotation of crops are now recognized to be manifold, including greater ease in maintaining the soil in proper physical condition; greater opportunity for catching and retaining the water which falls upon the soil, and more economical use of it. Insects and diseases are more easily combatted, and increased vigor of the plants results in increased yield. In addition, labor, manures and fertilizers are more economically used with benefit to the farmer, farm and the nation.

THE PUBLIC-SCHOOL TEACHER IN A DEMOCRACY

By HENRY R. LINVILLE
NEW YORK CITY

THE present wide-spread interest in the economic situation of school teachers in America has its sentimental foundation in the recognition of the generally beneficent relation of the public-school system to the people. With the gradual disappearance of ignorance and open cruelty among those who teach, and the establishment of a more perfect organization of the machinery of education, there has grown up intelligent interest and admiration of our school system in our own and in other countries. We, as well as our foreign admirers in educational lines, do not overlook the sad existence of evil conditions in outlying districts, but the energy of money and organization is being directed to the wiping out of these black spots on the map. Except for the occasional spasmodic anger aroused by local policies, there is general satisfaction with our educational system.

And yet, when we observe the great body of personalities, men and women alike, that transmit the learning of the ages to the young, the conviction must slowly dawn upon us that in proportion to their opportunities the teachers of elementary and high schools in this country do not measure up to the requirements of the situation. The ineffectiveness of school teachers in the most important functions of teaching is general, and is tacitly recognized by the thinking public. The exercise of commanding influence by them in any branch of social activity is unexpected, and is almost an unheard-of thing. We do not expect from this body of public servants constantly in touch with social conditions effective leadership, or the suggestion of important constructive ideas. The originators of ideas for the betterment of mankind do not look to school teachers for support, or even for understanding.

However, students of social life in America, know well the wonderful advance in the quality of teachers within the last hundred years. It is known that the schoolmasters of our English and Dutch colonial ancestors were generally social derelicts, failures in everything else, and much given to intoxication. We may safely claim that the advance in knowledge and in respectability in the ranks of those who teach has been greater than the advance of society generally. This hopeful fact might render unnecessary critical studies of the personnel of the profession of teaching, if it were not that new ideas in education urgently demand a hearing. These new ideas are concerned with the development and perfection of natural tendencies in the individual—which, if properly directed, would bring him into more sympathetic and efficient relation with society. It is the purpose of this article to show that the average teacher of to-day is not an efficient agent in social advancement. There still persist in him low or vague ideals of conduct. His mind is hidebound, and he is indifferent to problems of a social or political nature. He is aggravatingly humble, and forms a willing block in the existing bureaucratic system of school government.

Persons of even moderately delicate sensibilities are certain to be surprised if they come in contact with many teachers or principals in any of our large cities. One must be limited in his acquaintance if he does not know men in high position in school administration in cities, whose brutality is evident in their treatment of persons beneath them in authority, whose manners and speech are so coarse that their companionship in polite circles would be avoided whenever possible, whose selfishness and narrowness are so intense as to account fully under the present system of school government for their advancement beyond their less assertive fellows. Coincident with the lack of refinement characteristic of some teachers in the public schools, there is so general a deficiency of positive, militant and constructive qualities that the profession in its entirety is noticeable for its lack of intellectual alertness, of moral courage and of social and political understanding.

The student of social conditions has no difficulty in assigning to its proper cause the fact that in every part of the country teachers are often treated with disrespect (tempered with occasional fear) by their pupils, and with patronizing indulgence by people generally. In spite of pronouncements by leading public men, and by newspapers on the great and useful work of the public school teacher, the basic conviction persists that the profession of teaching is customarily followed by men who do not possess the force and manly power and the love of wide activity that characterize men who engage, for example, in law or finance. When the profession is entered by forceful young men, the relation is frequently a temporary one to be given up later for "something better."

The average high-school faculty is a heterogeneous composite of training and ability—a few forceful and several weak characters frequently with only normal-school training, a few college-trained men of ability not invited into college work, and more college men who never would be invited. When all are together the quality of the mass is distinctly commonplace, and does not contain the power of self-stimulation. There is among them an undercurrent of feeling that they are second-rate. This apologetic attitude is directly traceable as a result to an ideal set up by the first universities, and maintained through the centuries with increasing power. The great idea of the colleges and universities has been that learning is the highest aim of education. They have attained their present station as the result of working out that idea.

In the undergraduate and graduate department of every university in this country to-day, those men who are planning to be teachers are definitely scaled by their professors, by their fellows and by themselves on the basis of their ability as scholars. If they show unusual ability they are set down as future college professors; if less ability, they are scheduled as possible college instructors. The slow ones fall into the heap of future high-school teachers, and are treated accordingly. As long as the present academic and social grading of teachers holds the high schools will have to be content with the less intellectual group, except in the occasional instances where the competition for college positions compels some able young men to take up a high-school career. A high-school faculty then is consciously second-rate, and they will continue to have that feeling, and to hold that place until society advances to the plane of broader and more human, and less exclusively scholastic ideals.

Naturally, one would expect the high schools themselves to begin their own reformation, but the ideas for it are coming from elsewhere, and the hearing for them will come in all probability from enlightened minds in other fields of education, or in other lines of endeavor. High-school teachers, it is thought, and they are so informed by their superiors, have enough to do to attend strictly to their teaching. As a class high-school principals and teachers alike do not think in any profound way, for they give no proof of understanding the social and political conditions under which they work as agents in a democracy. They have no clear and adequate conception of the social and political functions of the school. Their lives are circumscribed and restrained by school laws, and often dulled by the insistent effect of hard, nerve-racking work. When the scholastic training is completed in some normal school or college, the subsequent thinking of the average teacher is incident to the occasional reading of methods. A very high percentage of teachers in the largest high schools of this country make no study of methods, and of the science of teaching, beyond what is necessary to pass examinations.

A layman would suppose that in a profession dealing primarily with the training and development of the minds of people one of the best characteristics of a good mind, self-reliance and independence in thinking, ought to be the possession of those who are in a position to encourage the development of this characteristic in children. It is a fact, however, that teachers even of the highest scholastic training, with extensive opportunities of forming judgments of their own, are unduly impressed by the opinions of persons in authority. With the leaven of intellectual capacity in the body of teachers as it is to-day, there might develop in the profession some general desire to study and understand the social and political conditions of life in this country and elsewhere, and thus to see the problem of how to make the school contribute to human progress—all this might happen if self-reliance and independence of thought were permitted to develop in our military system of school administration. There is probably no school superintendent in the country who would not urge his teachers to read and contribute from their thought to the solution of academic problems. He would welcome independence of thought as long as it is purely academic. But it is a noteworthy fact that in general the opinions of teachers on questions of school administration with local reference are not wanted. If the opinions expressed happen to be in opposition to those held by the "government," the teacher is guilty of "insubordination." Insubordination is anathema pronounced by principals, school superintendents or boards of education against offending teachers with such accompaniments of tyranny that it is small wonder that teachers are most anxious to inquire what their superiors want them to think or want. The writer was once informed by a superintendent of schools of extensive reputation that in his opinion a teacher who complained of the conduct of a superior officer should be punished for so doing, no matter whether the complaint was based on facts or not. Under those circumstances moral courage would seem to approach foolhardiness.

In large communities where the individual teacher is unknown and ignored, and the school government, only, makes representations to the people, the security of the teacher resides in occasional state and municipal laws designed to protect him from the machinations of political parties, and in his ability to keep his mouth shut and support the administration. His advancement to the highest positions depends not on the possession of unusual ability, but on his capacity to "mix" and make fortunate acquaintances among the officially powerful. In one of the largest cities of this country, it is common among men who are ambitious to hold high positions in the local educational system to make it a point to belong to as many dining organizations of educational officials as possible, to attend public installations of principals, leaving their classes to be cared for by the stay-at-homes, and to put officials of influence under lasting obligations to them by promoting subscriptions for the purchase of expensive presents, under the guise of sincere appreciation. The plan works, partly because of the emotional power of mutual felicitation, and partly because the administration is too busy to search for abler men who do not push themselves into the official horizon. All this is politics of a subtler kind than any the ward politician knew when in the same community he was the brutal power to be feared and flattered by the hopeful teacher.

The law protects the teacher in his position from the party politicians, but it does not protect the public, and the public makes no attempt to protect itself against the imposition of numerous teachers who have failed to "make good." It is practically impossible in certain of the large cities of the country to dismiss a teacher or a principal for incompetency. He can be harassed, but not dismissed. To a considerable extent custom and state or municipal laws insure him (in the case of teachers) an increase of salary as the years are added to his tenure of office.

The law which protects the teacher from unscrupulous interests strengthens and emphasizes the idea that public positions belong to the holders, and not to the public itself. The facts that a poor or low-minded teacher or principal may not only do infinite harm to human character in formation, but that he also *fails to do infinite good,* have not generally been taken into consideration officially in the best organized school administrations. If any one ever should suggest the idea that by the failure of a teacher to do constructive good in his position he thereby forfeited it, he would be set down as a "dreamer." Teachers and principals have been dismissed for open cruelty or viciousness, but not often for poor teaching, unsympathetic nature, low-mindedness, vulgarity, mental stagnation, and probably never solely for failure to contribute something to the moral and social uplift of a little community—the school. So general is the idea yet among teachers that their business is simply to "teach." A superintendent would need to be strong indeed with his community, if he should undertake to dismiss his inefficient teachers. The worst of them have their "influential" friends, and the argument from "bread and butter" is well-nigh invincible. Our conception of the importance of education in the national life must become more clear, and our belief in education more sincere. Perhaps then we shall have advanced to the position that the selfish, incompetent agent of education shall not defeat or hinder the purpose of a great public movement, no matter what his personal needs may be.

The presence of inefficient and ineffective workers in the teaching profession undoubtedly has much to do with the present low salaries of teachers. The kind of work done, and the quality of it on the whole, have not been good enough to enable organized education to compel the payment of better salaries. Whatever complaints we may make of the dominance of the dollar in American life, the incontestable fact exists that the public that pays out three fourths of its taxes for protection of life and property willingly, pays out one fourth for public education grudgingly. Why? Largely because the people are not seriously impressed with the implied claim that the kind of education they are getting is worth that much. It is altogether likely that continual agitation will result in teachers obtaining sufficient salaries, perhaps even before the ideals of educational practise are modified in accordance with the needs of human life, and before the people insist that the inefficient workers shall not feed at the public crib. In that case the people will be paying for something they do not get. Their protection finally must lie in knowing what they want in education, as they know what they want in food, but paying for it on the basis of the best it can mean to them, instead of on the basis of the supply.

The wide-spread agitation for an increase of the salaries of teachers has emphasized the fact that teachers display more enthusiasm over a possible rise in salary than they do over any other movement looking toward their professional advancement. Of course it is true that nothing is more important than the wherewithal to feed and clothe the body, and keep it in health. But after that is attended to appropriately, the members of a profession supposed to be contributing to human progress might reasonably be expected to have other enthusiasms, such as intellectual, moral and esthetic. One who has witnessed at close hand the fury of a campaign for equal salaries for men and women teachers in the largest educational system in the country ought to have illuminating experience bearing on this point. When both sides to the controversy spend days of time, and much energy and money, employ dishonest or questionable methods to obtain the help of influential citizens or officials, accuse one another of rascality in public meetings—when men and women teachers do these things in the heat of their anxiety for higher salaries, the idealist who strives for the development of intellect, morality and beauty, must stand aside abashed and all but confounded.

Continuous and earnest as the struggle is for higher salaries, great numbers enter the profession every year, if only for a short time. It is probably true that to a large extent men and women alike take up teaching, because its returns in money are more immediate and better, at least at first, than an equal amount of struggling for an economic vantage point would bring in other fields of human activity. Among teachers there is a constant increase in the freedom from such economic competition as is necessary to hold a position once obtained. Even to obtain the position in the first place, the competition consists in a protected endeavor to increase the quality of formal scholastic preparation, rather than in a sharp rivalry of manly or womanly qualities. Competition between persons of good ability in the profession of teaching is rare. The very scarcity of teachers in all parts of the country indicates that the competition can not be sharp. It is but natural that timid persons, or those doubtful of their powers, should drift into teaching as into a safe harbor. Having once become settled as teachers they tend to grow content and inert.

Almost the sole suggestion now offered for the improvement of the great body of citizens who teach is to increase the pay. The belief seems to be that a better class, of men especially, would enter the profession. To a certain extent the result expected would take place, but it is very doubtful if remuneration for teaching ever could or should be so great as to draw able young men from pursuits whose chief human interest is that they are profitable. There will, in all probability, always be professions in which more money can be obtained than by teaching. When educational systems undertake to compete with the corporations, for example, the educational systems must lose both the contest and the moral standing they should hope to win. The great danger is that higher salaries may add to the inefficient workers who are already in the work for the money, and thus tend to perpetuate a low ideal of service.

The idealist would have a gigantic task before him if he should undertake to substitute directly for the ideal of money the ideal of unselfish public service. The "practical" man would admit that "public service" has a pleasant sound, but "human nature" demands pay for its work. This is sadly true, even while men's thoughts dwell upon the high purpose of education. They remember the pay, while their souls should thrill with the mighty music of a great idea. True education develops power through knowledge, disseminates truth, instills self-reliance into the minds of the young, teaches the common rights of men, breaks the bonds of unreasoned authority and frees the mind of the future citizens of the republic; it gives them strength to withstand adversity, and leads them to love the beautiful, and to discriminate in all things that bear upon the daily joy of living. The practical thing to do is to put aside the fear that "human nature" is going to stand in the way of the best that can come to the race. The inevitable process of evolution will take care of that, and give us a new and finer human nature. Then the question will arise how to put the true, ideal education into practise, and how to obtain the workers to carry out the purpose.

Among the thousands of "settlement" and other kinds of social workers in the cities of this country there is a sympathetic interest and a point of view which if enlisted in public education would be productive of enormous good. Through the medium of the established and natural relation of teacher and pupil, the human purpose of the social worker now so fraught with discouragement and barren in results would become practical. There is hardly any question that many of the generous spirits who give their lives to the amelioration of social conditions would gladly work through the agency of public education if they could. The school is so dominated now by the idea of formal education, and "what the colleges require" that considerations of the physical and spiritual welfare of people seem merely incidental. Moreover, the administration of school systems is so autocratic, and the officials often so overbearing, insolent and petty, that finer spirits prefer to ally themselves with other movements. The loss to organized democracy of these finer men and women is great, but more serious still is the loss in a supposedly democratic country of the opportunity to encourage the development of democracy by teaching the principles of human right and duty in the schools and practising them in the administration. No amount of knowledge learned as the result of perfect machinery of organization can justify the neglect to develop democracy through our system of public education.

The officials of administration in school systems in cities in America consist usually of a board of education appointed by the mayor of the city and one or more superintendents elected by the board of education. The members of the board of education are business men representing any profession except the teaching profession. Their absolute ignorance of educational ideals is not considered a bar to their usefulness and probably is seldom taken account of at all. The idea is that the board of education represents the citizens, and supervises the financial business of the system, while the superintendent looks after purely professional or technical affairs. But the effects of the acts of both sets of officials can not possibly be kept distinct. Every town and city in the land has its bitter quarrels between the board of education and the supervising officers. Each side is more or less ignorant of the point of view of the other and indifferent to the point of view of the teaching staff. All this is loose administration because there is no unity of purpose and no centralization of responsibility.

Now, there is a very evident centralization of responsibility in the hands of technical experts in our fire departments, boards of health, and frequently in our police departments. What is the reason that intelligent teachers may not hope for promotion to positions of administrative opportunity, if firemen may? Is it not true that citizens generally would prefer an honest and able policeman as chief of police to any able but untrained and hence ignorant citizen?

The assertion is often made that teachers are not practical, that they know nothing about business. Even if that were true, it would be an argument against the average teacher and not against the idea of giving trained citizens the opportunity to direct those affairs they know most about. With the agency for training ready at hand, it would be strange if we could not develop men with initiative to plan and skill to direct, equal to the combined abilities of those who now control our school systems.

An arrangement by which teachers might advance as they prove by their constructive ideas and their efficiency that they are fitted for something else that the service requires, would be of enormous benefit to the educational movement. The certainty that, for example, the supervisor of manual training in a large city would be a man from anywhere who could show from his published contributions to the thought on his specialty that he was a master in it, as well as a teacher and a man of unquestioned quality and ability—this would encourage the young teacher to develop to the limit of his powers. When a career of study and effort carries a man to a position of great trust and responsibility, the individual has obtained due recognition, and the cause profits by having an efficient servant. When the position is obtained without full proof of fitness, the individual gets what he does not deserve, the administration deceives the public, and insults every fit person in the service.

Assuming that the people will in time care enough for public education to want it administered for the best results obtainable, it ought to be feasible to establish a system which would be effective and not become selfish with age. If systems of taxation can be submitted to the consideration of the electors, systems of education ought also to be within the range of the average intellect. We should scorn to employ a board to do our thinking and acting on the tariff question; it is the privilege of our American manhood to do that ourselves. Why should we be so willing to accept continually the judgment of educational "experts," and thus cut ourselves off from greater proof of our claims to social and political freedom.

There are questions of large import in education that could grow into national issues, and be crystallized into shape by the collective thinking of all the people. It is not inconceivable that some of these might occupy the attention of congress to the exclusion of the usual petty private interests of importunate individuals and communities. Other issues of a purely local nature, state or municipal, would fall for settlement to the sections interested.

There could be a member of the President's Cabinet, a Secretary of Education, who would be presumed to represent the judgment of the majority on national issues in education, and with his department could have clearly defined relations to the state and to the municipal or other local officials. The state and inferior boards of education that touch intimately the privileges of parents, teachers and children should be elected, and subjected to the will of the people through the principle of initiative and referendum. That development of democratic government would make it impossible for officers of education to command arbitrarily the inauguration of policies about which neither the people nor the teachers had been consulted.

The power of initiative and referendum resting with the people entirely, or in part with the teachers, would not necessarily be a hindrance to the work of the local boards, but it would keep the interest of all alive to the welfare of the schools. It would encourage and demand greater knowledge of educational questions among the people. It would crush for all time the autocratic spirit that rules sullenly in the seats of a democratic institution. The existence of the officious, overbearing and dictatorial superintendent and principal, and the timid, sycophantic teacher would become impossible. Not only must the relation of the boards to the schools be a democratic one, but the school within itself must be organized on the basis of the same idea. Teachers and pupils have rights which the autocratic principal of to-day tramples upon with impunity, and he is upheld by the officials who created him. The safety of the republic demands the abolition of such a tyrannical condition.

A rehabilitation of organized public education along the lines of the open and just recognition of the rights of all concerned, seems a necessary prerequisite to increasing the efficiency and effectiveness of all persons engaged as agents of education. The fair, honest and public-spirited administration of the schools is a necessary preliminary guarantee to the people that public education is a movement for human progress, and for nothing less.

CELIBATE EDUCATION TO-DAY

BY E. S.

IN our public schools are half a million teachers, of whom about four hundred thousand are women. Of these latter over half are spinsters or, according to official investigation and correspondence, have taught eight years and upwards. They have crossed the female dead line of matrimony, having reached the age of thirty.

The proportion of "old maids" is even more striking according to the estimate of school officials in some of our larger cities. In San Francisco, Pittsburg, Boston, Philadelphia, Buffalo, Denver, New Orleans, Nashville, Chicago and Cincinnati the figures run from 50 to as high as 80 per cent. with a general average of about 70 per cent.

These pedagogic conditions have grown upon us so gradually that we have not stopped to consider their significance. It is, however, an entirely modern development, really of the last fifty years. Less than half a century ago men formed nearly 40 per cent. of the teachers; they are now hardly 20 per cent. Some of the largest cities show still greater disparity between the sexes. In Boston and St. Louis, each, men are only 10 per cent. of the teachers; in New York and Indianapolis, 9 per cent.; in Cleveland, 7 per cent.; in Philadelphia, 6 per cent.; in Chicago, Detroit and Richmond, 5 per cent.; in Minneapolis, 4 per cent.; in Omaha, 3 per cent.; in New Orleans, 2 per cent., while Youngstown, O., has not even one man in her 188 teachers. Our centers of population are usually the most advanced in any social tendency and the small number of men employed in them may be taken as an indication of the drift of the whole country.

Throughout this paper it is to be remembered that to all general statements there are exceptions, both numerous and brilliant, and further that these theories of what is best to be done rest upon the interpretation that one investigator places on the data of the past, and the phenomena of the present, including testimony in the printed utterances of other workers in the same field.

The era of celibate education is on us and it behooves us to take our bearing to see whether we follow a safe course. For the male, we no longer have any doubt, he has been tried and found wanting. He dominated teaching for centuries as a celibate and now he is nearly displaced. It can not be said that he was superseded, because there were two sexes in the schoolroom as women were constantly engaged in teaching as far back into the middle ages, certainly to a considerable extent in our colonial period. The proportions now are reversed, women being in the majority instead of men. The work of men was deficient because bachelors can not really know life. Our civilization is based upon the family as a unit and only married persons really know the duties and demands of our social structure. As education is nothing but preparing young people to take their places in the framework of life, only those who know what that life is can adequately guide these tender feet.

We tried to supply what was lacking by introducing woman, and at first her natural tact, her sympathy and her deference to age-long authority made her popular with educational management after the first shock of conservatism had passed by. With the advent of the public school system her numbers increased rapidly, especially when she readily accepted a lower rate of compensation.

As each sex is only half of the sphere, is there anything in the temperament of woman that will enable her to come nearer filling the other half herself than her brother did? Just like him she is handicapped by the impassable limitations of sex, and, as with him, her nature attains its full measure only through matrimony. The most fully developed woman is the mother, next the wife, and least of all is the "old maid." This last is entirely a modern type, scarcely going back a century, and therefore her capacities are untried and unknown. It may be said she discharges a new function among the many always being created by our civilization, and has come to stay. Time can alone decide whether any innovation will survive, whether the apparently temporary will become permanent. But the question of sex is the most constant and prevailing of all in the interests and relations of the race, and the main features are neither of to-day nor of yesterday, but of all time. Some phases of woman's temperament are the product of the evolution of the ages, and are fixed. A reference to one or two of these may throw some light on this problem.

There are unquestionably two considerations that make the chances of women succeeding alone in this path more doubtful than those of men. First, is her mother instinct noticeable even in little girls playing with dolls. She grows to womanhood with the idea of queening it in a home of her own, least of all is it a part of her dream to rear children of other women. It is a frightful wrench to her whole nature to give up these aspirations for which she is not at all responsible as they are an inheritance to her from the millions of generations before.

The demolition of this age-long air castle brings about a change of her nature, more usually the souring of her disposition. It is well known that she suffers from nervous troubles much more than the man teacher and it is not to be wondered at. If we are to put any reliance at all upon universal attitudes and firmly crystallized expressions, her married sister, her parents and her brothers, even the children in the seats before her, all look on her as a failure in life, and, worst of all, she feels the same in her heart. Such disappointment would acidulate the sweetest spirit. Besides, she is leading an unnatural existence, dealing with children of the same age twenty, thirty or forty years, while the vast bulk of women have the care of one brood only from marriage to death. The constant strain on her temper within the school and without it makes her either querulous and harsh or flabby and indifferent—both states disastrous for discipline.

For the interests of the student, and consequently of all the race, is it a good model to set before maturing minds that the unmarried woman is the best type of all? Still more, is it wise to have examples of mannish women, as so many of them inevitably tend to the paths that men tread, after admitting to themselves that they are practically excluded from the chosen sphere of women, the home? Many of them turn to money making with all the avidity of their brothers. We have seen such exhibitions of greed and contentiousness among the women teachers in two of our largest cities when they have banded together for an increase in their salaries, going to much greater lengths than men would dare to do under such circumstances. The influence of all this will be felt in time upon the characters of the young.

All these weaknesses in the woman teacher have brought themselves to the surface; they are inherent, and therefore incurable by any method of selection or supervision. If we add the fundamental argument that we have derived from the test with men it seems a foregone conclusion that the celibate female teacher will fall just as far short as her celibate brother; she will fail in the schoolroom just as he did.

Failure is the lot of each because each is abnormal. "The normal citizen is a father or mother," thus tersely and truly does the president of the United States express the sentiment. If this is so and it has to be, who can properly guide young persons into that realm except normal men and women as teachers?

Another deduction from this premise is that we must have both sexes instructing the young. The difficulty with the male has been settled, we no longer require him to be unmated. On the other hand, it is almost an unfailing query on the part of appointing officers whether a male applicant is married or not. In numerous instances the preference is unhesitatingly given to the one with the wife.

This solution, however, should be impossible with women. It is abhorrent and disgusting to the average person to think that men should allow their wives to be breadwinners unless for special reasons. Again has Mr. Roosevelt summed up the case when he spoke of men as the home providers and women as the home keepers. This is the result of æons of evolution and any general breaking down of this line of division between the duties of the two will end disastrously to both. There can be only two causes for a wife to be in charge of a class, either she has stifled all of the instincts of femininity or her husband is incapable of providing for her. The latter is often justifiable because of misfortune or loss of health. But as young persons can not discriminate, the model before them is terrible. They can only see that the husband is incompetent or the wife is unwomanly, miserly and penurious. A horrible ideal it is to set before them that the chief aim of women in life is to make money instead of to make homes! In spite of this spontaneous repugnance there is a tendency to employ married women, due most likely to an unconscious feeling on the part of educational officials that the "old maid" is too abnormal. It is estimated that in San Francisco 5 per cent. of the teachers are married women; in Denver, 4 per cent.; in Philadelphia, 3 per cent.; in Boston, 2 per cent.; in Chicago about 2 per cent.; all a growth of a very few years. This is a tendency that every one who at all considers the relation of the sexes and the course of development must deeply deplore. The "old maid" in the school is an abnormal exemplar but the wife is a thousand times worse. The woman who neglects the highest, holiest—in fact the only—duty of woman is a hideous monstrosity to teach duty to others.

The best type of male teacher has been discovered after long and wide search—the married man. What is the best kind among women, it is still more important to learn, as we have settled down for the present beyond all doubt to coeducation and to having a large majority of women teachers, whether good, bad or indifferent. The general employment of married ones is repulsive and vicious. The single ones beyond thirty are unbalanced. There is left only woman before that age. She is still normal, still cherishing matrimony as woman's work in life evolved for her through long cycles of time by biology, physiology, sociology and the whole environment of existence. Her path has been marked out for her and the laws of her progress along it laid down by powers far above the scope and the strength of the race to alter. So long as she looks forward to the goal of the wedding she retains the feminine temperament. From the time of maturity until she turns aside from the broad road that the most of her sisters follow, she is almost at the high tide of woman's life. It is then her disposition is most sympathetic and her ideals the clearest and strongest. She is then the most vivacious, the most animated, the most energetic and the best fitted for training the young, because the most companionable with the girls and the best example of womanly graciousness. If we can not have the highest type of normal woman, the wife, we must come as near as possible.

If these golden years, however, are to be taken from a woman's life she ought to be adequately compensated. Salaries now paid should in most cases be increased 50 to 100 per cent. Such a rate in every locality would command the service of the brightest and most attractive women, who are usually the most intelligent and the healthiest. There would thus be a union of the highest qualities of character, intellect and physique. The objection of cost comes to nothing when the sacredest and most important concerns of life are involved. Of course, the women now in the service should be retained unless they would voluntarily take the higher rate for the limited time. The vext question of age can be easily avoided by placing the limit eight years after high school graduation and five or six after collegiate. There would at the same time be a splendid example to the girls as most of these teachers would marry before the term expired or shortly afterwards. The girls would thus be learning something about the highest duty of life, a kind of inspiration that is given nowhere in our schools now except by fitful instances. It must be remembered that there is a more solemn obligation of marriage than ever before if racial suicide is to be stayed. Fashion and the social system are insistent upon small families, and it is only by universal marriage that the native stock will reproduce itself. It does not do so already in some sections, and it is significant that in those places the spinsters flourish. Our highest institutions, the state and the school, should not encourage the increase of old maids, as their multiplication spells death to mankind. Vestal virgins are a luxury that prosaic America can not afford.

As a corollary with the limitation upon the age of women teachers there would need to be a certain number of men, not over one fourth of the total, to serve as permanent directing heads. This ratio of the sexes is entirely in keeping with the teachings of evolution. Two principles of sex relations seem to be established in these cycles of experience: (1) That both boys and girls are almost wholly controlled by the mother up to the age of twelve or fourteen, with the father's influence becoming more pointed after that on the boys and the mother's continuing over the girls; (2) that all pioneering initiative work, executive management, should be by men. With the men as principals and assistant principals in every schoolhouse, with them as directors of special studies and heads of departments in the higher grades, there would be a solid core for the flitting women teachers to group around and get inspiration from.

These men could be employed on a scale suitable for attracting native strength and ability. They would be sure of a life career in this calling after once having proved their fitness. In order that they should be examples for the youth it should be stipulated that when their usefulness ended their connection with the system would also cease. Without any pension or dole of charity they would be a standing stimulus to the boys that each should look forward to taking care of himself, not depending upon his neighbors or his government.

This plan would cure two difficulties of the present system. First the whole scale of pensions would drop away, as of course there would be no thought of so rewarding the female teacher. Second the disgraceful squabbles that take place periodically between the sexes over the question of equal pay for equal service would offend the ears no longer. Each sex would be hired on the true basis of compensation within its own ranks. That logical fallacy, such a fond subject of dispute, the equality of work of the two, would appear no more. It would be plain and above argument to every one that there is no such thing as men and women doing the same work in the schoolroom or elsewhere, and consequently to speak of equality of the two is absurd. The relation is far higher than that of equality, it is that of indispensability. It is the same as exists between the two halves of a circle or between the center and the circumference.

For some places, although the general rate of compensation would have to be raised higher, the total expense would not be very much greater. There would be no pensions, and instead of appropriating public funds to people who give no service whatever every dollar would get its worth in the devoted labor of both men and women teachers.

The school next to the family trains for life, for conduct, for character. The best method of development is that of example. What better model for these maturing natures than a teacher who is a success? Success for women means marriage. This notion is entwined in our very fibers so that we look upon the "old maid" as a failure in the great female game of life. The man who can not care for his family and for himself, who becomes a burden upon the goodness of his neighbors, is equally considered a failure. It is not a good pattern to set before the youth that the leader, man or woman, who daily instructs them has not succeeded in the great battle of the world. The schools should have the best and, in the long run, success, for the great bulk of mankind, is the proof of the best: competency for the man and marriage for the woman.

THE INADEQUACY OF SPEECH

By Dr. CHAS. W. SUPER
ATHENS, OHIO

ALMOST all the sounds that the human voice is capable of producing are used to express thought, feeling, or will. Many of these sounds are incorporated in articulate speech; but not all. It is to be remarked further that the term "articulate speech" includes many sounds that are not vocal, in fact the large majority are only modifications of vocal utterance. The most peculiar of those occurs in the language of the Hottentots: they employ sounds produced by inspiration or by means of the air in the mouth. These sounds are four in number and have been described as the "interjection of annoyance on the part of the owner when the china falls, the drawing of a cork, the giving of a kiss, and the sound of encouragement to a tired horse." They can be learned only from the natives by direct communication, since it is as impossible to represent them graphically as it is the croaking of a frog or the wail of a hyena. At least one writer maintains that they are the bridge over the gulf between the speech of man and the cries of animals, and are the primeval utterance out of which language was developed. No one tongue employs all the sounds which the human voice is able to produce, or even a majority. The instruction books for English place the number at about forty; but this is far from being all that are in use. Some languages, like the classical Italian and especially the Finnish, in both of which the vowels are numerous compared with the consonants, have few sounds and such as are easy of utterance. Conversely, the Russian employs combinations of consonants that it is almost impossible for adult foreigners to produce.

It must be remembered that a literary language is an artificial creation. Even the best instructed people do not speak as they write. The national adjective by which a language is designated is a much misunderstood word. England is a comparatively small country, yet to the ear there is much diversity in English speech. This diversity grows slowly less and less with the advance of national education, since by this means each rising generation is gradually led to conform to a common type. Appleton Morgan, the president of the New York Shakespeare Society, affirms that the members of Queen Elizabeth's parliament could not understand one another. This statement does not mean that the dialects of the different counties were as diverse as if they had been foreign tongues, but only that the diversities were of such a nature as to make complete reciprocal comprehension impossible. At this day the speech of the outlying districts differs to a greater or less extent from that of the capital. We may see, or rather we may hear, the same thing in France and Spain. Although Italy, until recently, had no political capital, Florence has for more than six centuries been the fountain-head of pure Italian, for the reason that the coryphæi of Italian literature were natives of the Florentine district. Much of the so-called Italian used by the uneducated bears hardly more resemblance to the literary type than another language. The same is true of Germany. What is regarded as the best German is spoken near the middle of the present empire, and to it foreigners usually try to conform. The Germans themselves are rather careless about the matter and are content to speak a tongue more or less marked by local words and by a distinctive pronunciation. The speech of Holstein, on the one hand, and that of South Germany and Switzerland, on the other, differs so widely that the natives of these regions who know only their mother dialect are unable to understand one another. I read somewhere that when Schiller first declaimed his early dramas before a middle German audience he was only half understood and that their merit was not appreciated until they were read aloud in a pronunciation unmarred by Swabian, the only kind of German he knew. Even so small a country as Denmark is not without its local peculiarities of speech. In the United States the diversities of speech are so slight as to occasion no inconvenience to a person passing from one end of the country to the other. The reason is that the Atlantic seaboard, roughly speaking, provided the norm for all the region extending westward to the Pacific. The Mississippi valley and the Far West are simply a linguistic extension of the East. The origin of dialects within a given language can only be accounted for hypothetically. They seem to be due to phonetic laws that operated on a larger scale in producing the wider divergencies of speech which are called languages. Limiting the statement to the Aryan stock, it is assumed by philologists that its eight branches are all descendants from one primitive tongue which was at first spoken by a comparatively small tribe. In the course of time the initial group scattered or was dispersed and each fragment became the nucleus of a new language. It needs but a superficial study of all the languages of Europe to make it evident that except the Finnish, the Magyar and the Turkish, together with a few smaller groups, they have many points of resemblance. When, however, we examine the structure of the three just named, we soon find a fundamental difference which is, however, common to the trio. The farther back we trace these eight languages, the closer becomes the resemblance. That the Irish branch of the Keltic differs more widely from the Russian than does the German is owing to the fact that the early settlers of Erin split off from the parent stock at a period prior to those of central and northern

Europe. This is the usual assumption, but it must always remain a hypothesis like so many other explanations of prehistoric phenomena. That English resembles the Scandinavian languages more than it does the German will not surprise any one who takes account of the early history of Great Britain. But who will tell us what brought about the transformation of the prepositive article, as we find it in English and German into a suffix which is its normal position in the Danish-Norwegian and Swedish, a transposition that seems to have taken place less than a millennium ago?

It is probable then that the same psychic cause led to the formation of dialects that in remoter ages produced separate languages. We know that the primitive Germans were a migratory people. At one time and another they are heard from in almost every part of Europe except Russia, because their movements were always southward or westward. When they were constrained to adopt a more fixed mode of life, there was but little intercourse between the different tribes; the divergences of speech, therefore, that had doubtless already begun to manifest themselves, became more and more marked until the introduction of letters among them virtually put an end to the distintegration. We find a similar phenomenon in South Africa. That continent from the equator to the Cape is occupied by the Bantus, except a few enclaves, whose dialects have a clearly marked relationship. No philologist ventures to affirm where the starting-point is to be found, although the general movement seems to have been from north to south. It is remarkable with what tenacity the natives of any particular district cling to the vernacular which they have received by inheritance. The student of the oldest German is constantly surprised by many words, and especially by a pronunciation still in use in southwest Germany, a region in which the language was first reduced to writing, that have undergone but little change in six or seven centuries. We find the same thing in other countries and in England. The unlettered still use words that are only found in the dialect dictionaries; and, as these are a modern innovation, they must have been transmitted orally through many generations. It is more than probable that of the words in common use to-day not a few are pronounced as they were in Shakespeare's time, or even in Chaucer's. There is a considerable number in the former writer with which he evidently makes puns and rhymes, but which lose their point if we give to them the pronunciation now assigned to them by our dictionaries. Evidently *beat* and *bait* were pronounced alike; so were *louse* and *luce, Moor* and *more, wode* and *wood,* and so on. I remember hearing in my youth in Pennsylvania some of my father's neighbors say "yarbs" for herbs, "coo" for cow, but by a singular perversity "cowcumber" for cucumber, "afeard," "pore" (poor), "sturk," together with several other archaisms. As the people who talked in this way were very illiterate and did not know whence their ancestors came, they can only have inherited, by oral tradition, the words brought generations before by immigrants from the mother country. It is strange with what tenacity the best-instructed persons are wont to cling to the past in matters of speech. When they can not do so in pronunciation, they show their fidelity to the same instinct in orthography.[1] They would greet with a guffaw the suggestion that they should travel, or live, or dress as did their grandfathers, or even their fathers; but they adhere to the spelling of the tenth preceding generation with a tenacity worthy of a nobler cause. In France no less than in England the spelling reformers have an almost insurmountable task before them. It is worthy of remark, however, that many words are pronounced by Americans more nearly as printed than by Englishmen. One seldom knows how to pronounce an English proper name from the printed page.

The primitive races exhibit a lack of capacity for abstract thought that is well nigh incredible. It seems almost impossible for them to generalize. Every perceived object has a separate name because it is a separate entity. Among the Innuits an older brother, a younger brother, a youngest brother, is each designated by a different term. The same is true of sisters; and when a brother, a sister or a father is deceased, still another word is employed when speaking of them. The Lapps have a word to designate the relationship of the husband of a man's sister, and another to designate that of men who have married sisters, but their language lacks one for brother-in-law. In this respect these and other languages are more definite than the English or the German. The Greek and Latin are still more careless in the designation of relationship by marriage. Herein all the primitive races have

[1] The following bits of verse, which I found somewhere, facetiously but truthfully represent some of the vagaries of our English pronunciation and orthography:

My wife had a dog yclept Cæsar,
As a gift he was given to please her.
One day he attempted to seize her,
Angry, perhaps, or to tease her.
She said: "I'd be glad if some bees or
Wasps would do him to death, or a freeze, for
I've no more int'rest in him."

Wife, make me some dumplings of dough,
They're better than meat for my cough;
Pray, let them be boiled till hot through,
But not till they're heavy or tough.
Now I must be off to the plough,
And the boys, when they've all had enough
Must keep the flies off with a bough
While the black mare drinks at the trough.

a well-supplied vocabulary. The range of their observations being limited, the natural tendency to loquacity manifests itself by multiplying words for the same or nearly the same object. It is not an uncommon thing to find persons even in civilized countries whose words are numerous in an inverse ratio to their thoughts. It is very much easier to talk than to think. The language-making faculty produces such a luxuriant crop of words that where the range of percepts is circumscribed it invents a new word for every possible relation in which they may be perceived. If the conditions of the primitive races were changed they would probably find their vocabulary sadly deficient. Under such circumstances it is likely that they would invent a new stock of words, using the material on hand as a basis as far as it would reach. Such we may suppose to be the case of the Eskimo and the Kafirs, if they were to exchange habitats. On the other hand, it needs to be said that this proceeding is not carried very far, but new objects are named by words used to designate them by the people that serve as intermediaries. We accordingly find among the Eskimo of the northwest a number of terms borrowed from the Russians, and, among the native tribes of Africa, words appropriated from the Arabic, the Portuguese and the English, always trimmed to fit the native vocal organs; for it must be remembered that they are learned by adults and not by children, whose vocal organs are sufficiently plastic to reproduce any sound accurately. The process may be seen among the Vai, a dialect of the Mande spoken to some extent in the republic of Liberia: lamp becomes "dampo," bowl "bowli" or "bowri," fork "furokia," hundred "hondoro," coat "coti," pillow "puro" or "puro," trunk "torungu."

When a language has reached a stereotyped stage and the people speaking it continue to advance in thought, there is nothing left for them to do except to discard it for another. This happened with the Hebrew. The library of the British Museum is said to contain ten thousand modern books in this language, among them most of Shakespeare's plays and even Goethe's Faust. It is hard to see how these versions can be more than a mere adumbration of the originals. It is simply impossible to express the subtle thoughts of these works in the rigid ancient tongue. The Jews themselves recognized this. When they undertook to discuss philosophical and metaphysical themes they had recourse to the Greek even when they wrote for their own countrymen. This language of unlimited resources and perfect adaptability to the expression of the minutest shades of thought had been so fully developed and had a vocabulary ready-made for abstract discussion that all who aspired to wide culture betook themselves to it. The New Testament furnishes evidence within the reach of every one. The Emperor Marcus Aurelius, although a Roman of the Romans, felt that

Greek was better adapted to give utterance to the inmost thought of his soul than his native Latin. It is doubtful whether an adequate English translation of his "Meditations" exists as yet. The late Carl Schurz, who was "master" of two languages in a widely different sense from that usually given to this much-abused word, was wont to say that for certain subjects he preferred the English and for others the German. In his mind each possessed excellencies which the other lacked.

Until recently almost all students of human speech accepted the theory that abstract ideas or concepts are its ultimate elements. It was held that the mind itself supplies an inherent basis of knowledge in all our cognitions. A name is a mere empty sign, a meaningless symbol, unless there be a preceding mental image of the object which it represents, or an abstract conception in the mind of which it is the sign. The mental image must precede the name, the abstract conception must be anterior to the sign, if it is to be understood. Ideas must precede the visible or audible or tactile signs. A child knows a great many things before it can speak the name. This being the case, the moon is the "measurer," the sun the "light-giver," from roots meaning *to measure* and *to shine*. Fifty years ago, Professor Max Müller worked out this theory with much detail and popularized it with a profusion of poetic imagery. At the present day, however, it is no longer taken seriously by the most competent judges. Most persons conversant with the facts admit that in nearly all languages there are roots that seem to express purely abstract ideas; but whether these are the oldest elements is another question. Dogs and other brutes know the names of objects as well as their uses although they never learn to speak the former. A careful study of the radical elements of many languages has led some philologists to maintain that the earliest words were a sort of cross between a name in action and an appended demonstrative. *To walk* or *to eat* would thus mean "walker-that-one," or "walker-he"; "eater-this-one," or "eater-he." In some of the languages spoken by tribes at the foot of the economic ladder words are used in a sense utterly foreign to our modes of thought. In the Innuit, for example, "he is my son" really means *he sons me;* "thou art my son" is *I son thee;* "he sons me" is equivalent to *I am his son*. We find a trace of this mode of thought in English owing to the lack of characteristic suffixes, as when Shakespeare says: "Cowards father cowards." Familiar examples of this dual nature of words are boycott, out-Herod, water, table, "move on," "get a move on you"; and many more.

The endeavor to give utterance to internal speech, as we may call it, has called into existence an astonishing number of word-forms to express number, person, gender and case. These various relations are indicated by prefixes, suffixes and infixes, or by separate words. In English the plural is, for the most part, formed by the addition of an s to the singular. This method is so simple that it could not be made more so. The exceptions are such plurals as oxen, mice, men, and a few others. On the other hand, the Hausa, a dialect of the Mande spoken in central Africa, employs at least seven different ways of forming the plural regularly either by the addition of another syllable or by reduplicating the final syllable with a euphonic change. The Latin has five forms for the plural. In the language of the Bullum and Temme the plural is made by means of various prefixes, *kil* "a house" becoming *tikil, pokan,* "a man" becoming *apokan,* and so on. On the other hand, in the Japanese the plural, in a majority of substantives, does not differ from the singular. Sometimes, however, it is formed by repetition of the singular, or by the addition of another word; but the latter process usually means something more than a mere plural. In the French a large number of plurals do not differ from the singular except to the eye. In the Italian the modification of the terminal syllable often adds a qualification to the root: it may indicate mere bigness, or bigness and ugliness, or bigness and fatness, or bigness and vigor. Conversely, it possesses likewise several modifying syllables to indicate the opposite qualities, as little and neat, little and lovely, or little and unimportant, or little and contemptible. The Finnish is provided with fifteen cases with which to express the various relations in which a noun may be used. Doubling this number for the plural, a Finnish substantive may appear in thirty different forms. Comparing this method with such languages as the French and the Spanish, in which case-relations are expressed by means of propositions, it looks like the extreme of complexity, or like an effort on the part of the Finnish people to resort to an intricate method for doing that which might be done just as well by a much simpler process. Again, if we compare an English verb with the same part of speech in Sanscrit or Greek we find a similar remarkable diversity. A Greek verb with its participles may take more than five hundred different forms to express person, number, tense and case. It must be evident that with such an astonishing variety of resources at command it can express shades of meaning in a single word quite impossible with a Germanic verb. The Semitic languages are, for the most part, very simple in the structure of the verb, having, like the English, only two tense-forms. On the other hand, they complicate matters by giving to the second person, both singular and plural, a form to agree with the sex of the person addressed. Although they lack a passive voice they indicate the passive state by the use of prefixes and vowels placed before or within the radical consonants. The inadequacy of even the most highly developed language to express abstract ideas with accuracy is strikingly shown by a study of the writings of a thinker like Plato. He had virtually no predecessors in the realm of thought in which his mind often moved. He had, therefore, to coin new words, out of preexisting materials, or to give to current words a new meaning. He usually chose the latter, thus laying himself liable to be misunderstood at every turn. His followers were, therefore, in the position of the shorter animals that try to feed on branches as far from the ground as the giraffe does. The result is that although his works have been studied and commented upon for more than twenty centuries, we are still told by some of his enthusiastic devotees, that the master is not fully understood. There is probably a good deal of truth in the assertion, for the reason that our psychic experiences are not only conditioned by our environment, but also by our mental structure. As the former can not be reproduced and as minds of like caliber are a prodigy we probably do not fully comprehend what the ancient thinker meant in not a few passages. The truth of this statement may be made evident by a simple illustration. We hear a certain individual say: "I am happy." Upon inquiry we find that his state of mind is the result of his having plenty of food and drink of a kind exactly suited to his tastes and that he cares for nothing else. Another person uses the same expression whose highest ambition is to possess the means to shine in society, but who is relatively indifferent to food and drink. A third person is a North American Indian, who has after long watching and waiting got into his power a mortal enemy whom he can now torture to his heart's content. With these let us now compare the ecstatic feelings of a Copernicus when after long years of study and reflection he had at last become fully convinced of the truth of the heliocentric system. Although all four have employed exactly the same sentence their meaning was wide, very wide apart. But even in less profound matters we can not fully understand a language unless we are thoroughly familiar with the conditions where it has been developed. In some of its aspects German is German the world over. But what different feelings come into our minds when we take up Schiller's "Tell" in north Germany, or in a foreign land, or among the scenes where the drama is laid! The Platt-Deutsch of the northern plains seems strangely out of place in the mountain region of the south. The converse is equally true. And what a feeble imitation of the real thing is the colloquial German of the United States or the French of Canada! The ancients were aware of this. Herodotus tells us that when the messenger of Cambyses came to Psammeticus, the dethroned king of Egypt, to ask him why he did not shed a tear nor utter a cry when he saw his daughter brought to shame and his son on his way to death, but gave those marks of honor to a beggar, replied: "O son of Cyrus, my own misfortunes were too great for tears," and by inference, too great for words. Similarly Malcolm says "Give sorrow words: the grief that doth not speak, Whispers to the o'erfraught heart and bids it break." And again: "Grief that is expressed in words Is slight indeed." Byron also speaks of the "suffocating sense of woe." When we read an author like Voltaire we feel that in his hundred volumes he said about all he had to say. He puts his thoughts before us lucidly and vigorously, but not profoundly. In the case of Goethe, on the other hand, who could think both scientifically and poetically, we often realize that in spite of the enormous extent of his works his language is not infrequently an indication of his thoughts rather than the expression of the thoughts themselves. The existence of Dante Societies, and Shakespeare Societies, and Goethe Societies has its justification in the conviction that the thoughts of these master minds can be fully understood only by the cooperation of many of inferior caliber. By thus combining and comparing the individual and partial views of a number of separate intellects, they may gain at least an approximately adequate grasp of the psyche of these prodigies.

Perhaps the most remarkable phenomenon exhibited by all the languages of the world is a process we can hardly call by any other name than deterioration. Take, for example, the Greek. Many of its oldest words are both longer and more sonorous than the later ones. But often even the earliest form shows evidence of weakening, abrasion and contraction. At least one consonant was lost in the period lying between the prehistoric and the historic. In many words two syllables are drawn together into one, or a shorter takes the place of a longer word. Sometimes the longer form existed for a time alongside the shorter, eventually to displace it entirely. Often the attenuated vowel e takes the place of the more sonorous a. It would almost seem as if when a word of two or more syllables having a traditional signification had for a time been in use it dawned upon the primitive mind that it could be shortened without losing its meaning. In Greek and Latin this process is not carried very far, but in French all the words derived from the latter language consist only of that portion that precedes and includes the accented syllable. We know that when an uneducated person tries to reproduce the pronunciation of a long foreign word or one that is foreign to him, he usually gets only a part of it and that part often incorrectly: education becomes "edication," sitting "sit'n," somewhat "sumet," the other "t'other," and so on with innumerable examples. This is the every-day process. But where and when shall we place the era of upbuilding? When were the fuller forms in use? The procedure that falls within our ken furnishes us with no answer to the question, not so much as an approximation thereto. Even those languages of which the study began only a generation or two ago exhibit the same phenomenon. The Bantu, the most widely disseminated speech of South Africa, presents many instances where two or more syllables are contracted into one, and where former syllables have left but a single letter as evidence of their one-time existence. As soon as a language is reduced to writing, or becomes a matter of study, and the rising generation is taught to pattern after its predecessors, the process of deterioration virtually comes to an end, unless only a small portion of those who use it fall under the influence of culture. In such a case the breach between the educated and the uneducated becomes wider and wider. This gradual divergence can be traced both in the Greek and in the Latin. A few persons continued to write the classic tongues as nearly as they could; but they eventually became unintelligible to the great mass of the people. Although Dante had a ready use of the Latin and wrote much in that language, he nevertheless composed a treatise to prove the superiority of the mother-tongue; and he felt that in this alone could he give utterance to the inmost thoughts of his soul.

It is remarkable that the course of what we are wont to call civilization is in a great measure parallel with that of language. During the Mycenæan age in Greece the arts flourished to a degree that seemed almost godlike to Homer's contemporaries. The historic era in Egypt and Mesopotamia, the beginning of which is placed about three thousand years B.C., is one of decline. The same is true of Mexico and Central America. Here not only the age of growth, but also that of decay, has been swept into the bottomless pit of oblivion. We see much and know nothing.

That thought embraces more than speech may often be inferred from a study of public speakers. When persons who are in the habit of thinking rather than talking endeavor to express themselves in public they are frequently at a loss. They hesitate, repeat, often use the wrong word, and are ill at ease for the reason that the vocabulary which they have at immediate command does not offer the exact terms they need. This is particularly true of mathematicians, who are proverbially poor speakers. Take another example similar in kind. I am translating from a foreign tongue into my own. I come across a word for which an equivalent does not at once occur to me. My memory brings into consciousness several synonyms, but all are rejected by my judgment as inadequate. My memory may be compared to a plane surface on which my judgment moves about like a flash-light until it discovers what I am looking for. Or I may come across a foreign word that has no English equivalent. I must therefore transfer it bodily or use an approximation. In such cases the dictionary rarely affords any aid. It furnishes me, perhaps, with a number of more or less equivalents, but it does not help me to select the particular word I am in search of. Again, assuming that Leibniz discovered the Differential Calculus, did he do so with the German, the French or the Latin language? Although we are not justified in assuming that the discovery could have been made by a dumb person, it lies within a sphere of thought where words count for little. There is abundant evidence to prove that many of the subanimals carry on elementary trains of reasoning which lead them to conform their actions to new conditions. They depart from their usual routine. In the child, thought and speech are developed, *pari passu,* but after a while the latter is no longer indispensable. They need a support just as they do in learning to walk. That thought and reason are not identical may thus be judged in its lowest forms by the conduct of certain animals and from the lowest races such as the Fuegians and Bushmen, since the reasoning powers of the latter always remain at the puerile stage, but also from those persons who have risen into an intellectual region where words are inadequate to express their ideas.

The generally accepted explanation of this tendency to abbreviate words spoken of before is that it is due to laziness, or a well-nigh irresistible impulse to follow the law of least effort. It is, however, more probably owing to the incapacity of adults to apprehend sounds correctly. Even with the utmost care on the part of the teacher and the learner, persons who have reached the age of maturity seldom succeed in acquiring the correct pronunciation of a foreign language. One may continue to add a reading knowledge of languages to one's repertoire as long as his mental faculties are unimpaired, but the capacity to imitate a correct pronunciation seldom continues beyond the age of about twenty. What is done by the child without thought and without effort is impossible to the "grown-ups."[2]

That the psychic life of man can not be fully expressed by language is further evinced by the predisposition manifested everywhere and at all times by mankind to come to its aid with the hands. Hence we have the plastic and pictorial arts together with music. The artistic instinct is nowhere wholly lacking; prehistoric man made rude carvings. A mere daub or a coarse wood-cut gives the beholder a clearer conception of an object than pages of description. The same may be said of a piece of statuary. Words set to music and rhythm in a simple air are more impressive than a mere recitation. When then it is supported by a musical instrument, or better still by an orchestra, the effect is greatly heightened. Even without words emotion can be forcibly expressed by instruments alone or by gestures alone. The orator Cicero is reputed to have said that the actor Roscius could portray the feelings more accurately in pantomime than he was himself able to describe them with words. The instinct or impulse that leads men to endeavor to give utterance to their feeling by rhythm and tones, often very unmusical to a cultivated taste, is almost as old as the

[2] A curious and amusing instance once occurred in my own experience. I was talking with an Englishman who dealt with the h-sound after the somewhat usual manner of his countrymen. Upon my alluding to his weakness in a jocular way, he became very angry, declaring that I had taken up a false charge. Yet in the very words of his defense he committed the peccadilloes against which he was defending his countrymen. On the other hand, I have known several Englishmen who admitted the bad habit and strove assiduously to avoid it.

race. Before the dawn of history there seems to have been in vogue the war-song, the dance-tune, the epic recitative, the religious chant, all accompanied by appropriate gesture and frequently by such instruments as the age could produce. The Orphic legends bear witness to the real or imagined power of the musical art. When in its infancy, it was usually accompanied by gesture and pantomime. We all can bear witness to the tendency of emotional individuals to fall instinctively into gesticulaton in order to emphasize their words. Popular audiences are so much more influenced by their feelings than by their judgment that they are often "carried away" by the commonplaces of a skillful elocutionist, but remain unmoved by the most profound wisdom of the statuesque orator. How contagious emotionalism is likely to be is strikingly shown by the anecdote Franklin tells about the effect of Whitefield's oratory upon his purse.

How jejune must be the psychic life of those peoples that are without any of these arts becomes evident after a moment's reflection. Even if their languages were far better adapted to the expression of thought than most of them are, their soul life would nevertheless be lacking in some of the most effective modes of utterance. It was doubtless this thought that Tennyson had in mind when he wrote:

> Better fifty years of Europe than a cycle of Cathay.

We need to remember, however, that the word *better* is used in this connection in the European sense. Yet John Stuart Mill is probably right when he says: "Few human creatures would consent to be changed into any of the lower animals, for a promise of the fullest allowance of beastly pleasures; no intelligent human being would consent to be a fool, no instructed person would be an ignoramus, no person of feeling and conscience would be selfish and base, even though they should be persuaded that the fool, the dunce or the rascal is better satisfied with his lot than they with theirs." He puts the case still more effectively in the words: "It is better to be a human being dissatisfied than a pig satisfied; better to be a Socrates dissatisfied than a fool satisfied. And if the fool or the pig is of a different opinion, it is because they only know their own side of the question. The other party to the comparison knows both." It is evident, then, that speech, when most carefully and conscientiously used, is but a feeble reflection of man's inner self. When, on the other hand, we consider man's liability to error, his passive indifference to truth and his proneness to deliberate falsehood, we must admit that language and fact do not often correspond with each other. While it is not true, according to the well-known saying of Talleyrand, that speech was given to man to enable him to conceal his thoughts, that is so employed in numberless instances who shall gainsay?

ZOOLOGY[1]

By Professor HENRY E CRAMPTON
COLUMBIA UNIVERSITY

IN the present series of addresses upon the nature and scope of some of the divisions of knowledge, zoology connects the natural sciences with those subjects that deal with human progress in physical, social, political and economic respects. Like the human and other sciences, zoology has arisen from that vague uncoordinated and unresolved mass of knowledge, the natural philosophy of not very remote times, which undertook to comprehend all there was of nature and thought. And again like the other sciences it is as such a branch of relatively late growth. In earlier times few men were sufficiently withdrawn from the affairs of the market-place and commerce and conquest, from politics and government and theological propaganda, to observe the phenomena of nature closely, to reflect upon their observations, and to summarize their deductions in the formularies of natural law. Not until human social structure neared the relatively settled condition of modern times did it become possible for men to differentiate as students of nature solely, rendering their service to the common weal as investigators of the less practical and more remote departments of knowledge. Now the sciences have become so great, so complex and varied, that it is impossible for a single mind to comprehend all that is included in one of them. So widely the impelling energy of research has driven the soldiers of investigation that only when, as in the present series of addresses, they return to the council-fires of an intellectual bivouac can they come to realize how far-flung indeed are the battle-lines of the armies of science—how rich and diversified is the territory from which knowledge has driven ignorance and superstition. And they must realize also how impossible it is for them to conduct their operations at all times in entire independence. The results of physics and chemistry are indispensable weapons for the biologist; geology takes the field with paleontology for the study of fossil forms; while on the other hand the advance posts of zoology provide the students of many a human science with a secure base of operations.

I need not speak of the inter-relations of the several biological sciences, for these have been sufficiently explained in the earlier dis-

[1] A lecture delivered at Columbia University in the series on Science, Philosophy and Art December 11, 1907.

courses. I shall pass directly to a description of the elements of the present science of zoology and of its history, so far as this is necessary for a clear understanding of the various divisions of the subject and of their connections; and finally I shall endeavor to show how through its human materials zoology articulates directly with other fields of knowledge.

Zoology is the science that deals with the structure, development and inter-relationships of animals, with the workings of their parts, their activities and their relations to their environment, and with the factors that determine their forms. We may recognize two great divisions of the subject, which are concerned respectively with static and with dynamic principles, though the materials of both divisions are the same—namely, all animals throughout the entire range from the highest to the lowest. It is of course clear that morphology—the science of structure—can not be absolutely separated from physiology—the science of function in its widest sense—for we do not know of organic structures that play absolutely no part in an animal's economy, even though this may be a relatively passive one; while on the other hand we do not know—in science at any rate—of a function that is devoid of a material basis. The division is made solely for the sake of analysis, and it depends entirely upon the point of view. Morphology treats adult animals, their different developmental stages, and, more naturally, the remains of extinct animals as though they were arrested in their living, but the dynamic aspects of organic life are so prominent and insistent that it is really impossible to ignore them even temporarily.

Besides dealing with the same materials, the many complicated problems of zoology are still further connected in that the central object of study for both the structural and physiological divisions is evolution. As we look back over the history of the subject from our modern vantage-ground, we can see how zoology began with ancient and medieval natural history, how from this parent stock arose the additional separate branches of anatomy, embryology, paleontology and distribution, how human physiology became comparative physiology which developed later into the broad and deep enquiry into all the activities of animals, their vital relations to one another, and their reactions to and upon the environment; and we can see how all these several branches were vitalized by the great principle of evolution. This whole history shows a steady progress through one phase after another toward the modern study of evolution, though the naturalists of the eighteenth and even of much of the nineteenth century were unconscious, in whole or in part, of the way their observations and views were contributing to the establishment of the doctrine of descent and to the partial description that can now be offered of the natural factors of evolution. As we shall see, the structural analysis of animals demonstrates the evolution of species as a universal process, while the broad study of the dynamic relations of animals is concerned with the causes of this process, as what we may venture to call the physiology of evolution. In brief, then, the great questions of zoology are the *what* and the *how* of evolution.

In view of the earlier lectures, it is unnecessary to speak at length of classification or taxonomy—the first division of static or structural zoology. Aristotle, who gathered and studied some five hundred of the more common animals of the earth and shore and sea, and the medievalists, Wotton and Ray, Gesner and Aldrovandi, were animated primarily by the instincts of the collector of interesting information. Linnæus, the great figure of the eighteenth century, rendered an immortal service to zoology (and botany, too) by introducing the present ordered system of naming and classifying organisms. But classification was to Linnæus an end in itself, he could not see that it was but a means to the larger end of understanding and expressing evolutionary relationships—that resemblance meant consanguinity. It remained for Erasmus Darwin, the elder St. Hiliare, Lamarck and others to appreciate this inner meaning which so vivifies the otherwise dead details of taxonomy.

The many connected details of animal structure and development and function constitute the threads, as it were, which are interwoven by comparative treatment to form the warp and woof of the fabric of zoology. Classification draws upon this fabric the pattern of genealogical connections, emphasizing those threads that run furthest, the so-called distinctive or diagnostic characters. And though the pattern must be altered here and there as knowledge increases, the zoologist feels that it has a real significance as a representation of evolutionary descent.

As more and more of the lower animals were brought by the microscope from the obscurity of their zoological underworld, as exploration revealed more of the creatures of previously unknown lands, as investigation became more detailed and intensive, comparative anatomy arose as an independent branch of zoology with distinct purposes of its own; and it gained its specific form and character from the studies of the great zoologists of the early nineteenth century—Lamarck, Cuvier, Geoffroy St. Hiliare, Goethe, Owen and Oken. These naturalists dissected and compared the various organic systems of animals, following them as widely as possible from group to group of the numerous vertebrate and invertebrate forms, and they and their followers have placed the doctrine of evolution upon the sure and broad foundation of comparative anatomy. The main principle of this department of zoology is that the varied forms of animals exhibit deep-seated likenesses that place them in groups related to one another not as the rungs of a ladder as Lamarck supposed, but rather as the branches of a tree or a bush; and such branches again like those of a tree bear smaller branches, and these reach to lesser or greater heights from the base level of primitive organization. Thus, anatomy holds that community of plan is an indication of genetic affinities, while modifications of a common plan exhibit the results of adaptation to different ends through evolution. The framework of the human arm is constructed out of the same elements with the same arrangement that we find in the leg of a cat, the flipper of a seal, the paddle of a whale, and even the wing of a bat, different though these structures are in function—and in these resemblances comparative anatomy discerns evidence of a remote common ancestry of men and whales and bats.

Extended through the study of tissues, or histology, to the unitary elements of organic structure—the cells—comparative analysis has brought the whole realm of organic nature under the sway of a great principle—the cell-doctrine of the botanist Schleiden and the zoologist Schwann. This important principle, propounded in 1838 and 1839, produced an immediate effect in unifying organic creatures, though many years passed before it was formulated in the terms employed to-day. In brief, it is this: All the larger organisms are composed of organs which in turn are constructed of various tissues, like muscle and nerve and connective elements; the tissues finally can be resolved into units of structure, the cells, which agree in possessing a central body or nucleus, and in their protoplasmic substance. The elementary nature of cells is still further demonstrated by the simplest organisms we know, which consist of one cell, nothing more and nothing less; while finally the starting point in the development of higher animals is always a single cell—the egg. Truly these are remarkable facts, when we consider the wide range of animal and plant forms.

Vast as the present knowledge is, the tasks of comparative anatomy are not entirely completed. Though voyages of exploration like those of the *Beagle* with Darwin, the *Rattlesnake* with Huxley, and above all of the famous *Challenger* have gone to all parts of the globe, though countless investigators have devoted their lives to the study of special groups like birds and mammals and insects and molluscs, every year brings to light new forms that must be analyzed and placed; while new discoveries in other departments often make it necessary to reexamine known series in the light of fuller knowledge.

While many naturalists prior to the nineteenth century were interested in the way an animal egg produced an adult organism, it was not until the doctrine of descent energized zoology that comparative embryology attained the independent status that it holds to this day. Harvey in 1650 had perceived that, in his own words, "all animals are in some sort produced from eggs." Bonnet and Haller, of the early eighteenth century, contended that the germ was a minute replica of the adult which formed it, a *multum in parvo* which simply unfolded and enlarged to produce another adult organism; Wolff, however, showed that this view lacked a basis in fact, and that as we now universally believe, embryonic history is a true development from the simple and unorganized to the progressively more and more specialized later conditions—that it is, in a word, an epigenesis. The great name of the infancy of embryology is that of Von Baer (1792–1876). This acute observer and thinker was struck by the similarity of early stages in the development of quite different adult animals. Birds and reptiles and even mammals pass through stages when they possess gill-slits like those of fishes, related to heart and blood-vessels like the similar structures in lower vertebrates; butterflies and flies and beetles are somewhat alike in their larval stages, when as caterpillars and maggots and grubs they not only resemble one another remarkably but they are also very like worms. Under the influence of the evolution doctrine, then becoming more generally accepted, Von Baer and a host of followers extended the science of comparative embryology until Haeckel in 1866 ventured to state the "Law of Recapitulation," or the "Biogenetic Law," in the following rigid terms: Ontogeny recapitulates phylogeny. (The development of an individual reviews the past history of its species.) Led by their enthusiasm many of the later nineteenth century zoologists followed too implicitly the lines of the embryonic record, though Haeckel himself, the most radical advocate of the law, pointed out that there are many serious omissions in the narrative, that false passages are inserted as the result of purely larval and embryonic needs and adaptations, while many alterations in the way of anachronisms have been made. Of late years there has been a strong reaction from the complete acceptance of the principle as a reliable mode of interpreting embryonic histories. But I believe zoologists generally feel that used with due caution the law has a high value for the student of evolution, and they realize that embryology is perhaps more significant in other respects than in showing exactly how in past times any given species has evolved. The present tasks in this department, now so thoroughly investigated, are to distinguish between the false and the true portions of the record, between the new and the old, and to ascertain the physiology of development, in order to gain a more complete knowledge of racial history and of the dynamics of organic nature.

The study of the fossil remains of animal organisms, or paleontology, is the fourth division of structural zoology, which as an independent branch dates back to the time of Cuvier, scarcely a hundred years ago. Vestiges of creation were indeed known long before that time, but they were variously regarded as freaks of geological formation, *lusus naturæ,* as remains of creatures stranded by tidal waves or cataclysms like the traditional flood, or again as the remains of animals formed by a process of spontaneous generation in the depths of the earth that had failed to reach the surface. It was Leonardo da Vinci of the fifteenth century who, anticipating the naturalists of later times, believed these vestiges are what common-sense says they are—simply relics of creatures that lived when the earth was younger. Cuvier was in a true sense the founder of paleontology; though a special creationist, he recognized that beneath their differences there were fundamental likenesses between recent and extinct animals. He assumed that cataclysms had closed the several geologic epochs whereupon new series of animals and plants were created upon the same general working-plans employed in earlier ages; thus he combined the idea of change in geologic time with a belief in supernatural creation. When, however, Lyell led geologists and others to abandon the cataclysmic hypothesis in favor of the doctrine of uniformitarianism, when the series of known fossil forms increased and the intrinsic value of the paleontological evidence became clearer, the doctrine of evolution finally claimed this field also as its own.

The nature of the case is such that the fossil record must remain incomplete, perhaps forever. For not all the animals of former times possessed hard parts capable of resisting the disintegrating forces of organic and inorganic nature, the rocky tombs of those animals that were embedded in the sands and silts have been crushed and rent asunder by the very geological agencies that at first constructed them. More than half of the earth's surface is now under water, while by no means all of the dry land is accessible. Only a few scratches have been made here and there upon the earth's hard crust, so it is little wonder that the testimony of the rocks is halting and imperfect. But what there is, a rapidly growing body of cold, hard facts, is in itself conclusive evidence of the reality of evolution. Researches like those of Von Zittel, Cope, Hyatt, Marsh, Osborn and Scott, demonstrate that, when they appear at all, the great groups or *phyla* of animals and their subdivisions succeed one another in that chronological order which comparative anatomy and embryology have independently shown is the order of their evolution. Then, too, there are those fossil types that link together groups now so widely separated, like *Archeopteryx,* which is at once a feathered reptile and a bird with reptilian tail and skull and limbs. And there are the marvelously perfect series of fossils like those which demonstrate the evolution of modern horses and elephants; and, finally, as the special creationist Louis Agassiz himself showed, some fossil series parallel very closely the embryonic record in modern types. No field opens more invitingly than that of the paleontologist. His tasks are to search the rocks everywhere for new fossil types to fill in the gaps of the lines of descent that at best can only be interrupted lines, and to show how these lines lead to modern forms or to divergent kinds that have ceased to be. And he will compare his results with those of students in other fields, who will assist him to formulate the working-plans for his own labors.

Zoo-geography is the last branch of structural zoology to attain an independent status. Many observers from Buffon onward had been struck by the fact that species of animals are not uniformly distributed over the earth, that they differ more widely as the observer passes to more and more remote localities, with more different climatic and other environmental conditions. But the meaning of these peculiarities was obscure until the doctrine of descent cleared their vision. Wagner, Louis Agassiz and Dana, Sclater, Murray and Wallace were the leaders of those who have brought together the immense mass of modern knowledge of animal distribution. From this many well-established principles relating to descent have been derived, though these have a deeper interest in connection with the dynamic problem as to whether differences in environment can actually cause species to transform, as Lamarck supposed. As a statement of the results in this apparently simple, but really quite complicated field would be misleading, I fear, from its brevity and general form, I will venture to present just one conclusion. Geographical isolation corresponds in a general way with the divergence of species in their evolution from common ancestors; thus widely separated areas have faunas that differ more widely in zoological respects than do those of neighboring or connected countries. For example, the Australian region has been cut off for a relatively long period from neighboring continents, and in correspondence with this isolation it contains the only egg-laying mammals known, as well as all of the pouched mammals like the kangaroo, with a few exceptions like our American opossum. Furthermore, groups of isolated oceanic islands, like the Galapagos and Azores and the clusters of Polynesia, are inhabited by lizards and birds and insects which resemble most closely the species of the nearest bodies of land. Such resemblances are most reasonably interpreted as indicating that the original progenitors of the island colonies were stragglers from the nearest mainland, whose descendants have undergone divergent evolution during succeeding generations.

Having, then, this vast store of fact and principle amassed through centuries by countless students, the zoologist is entitled to speak positively when he finds a law like the doctrine of evolution that reviews and summarizes the whole range of animal structure. The well-established facts of zoology are the reasons why he asserts with a decision often mistaken for dogmatism that evolution is a real process. The further question, why is nature so constituted that evolution is true, is an enquiry that does not fall within the limits of zoological science.

We now come to the second great division of zoology, which as a whole is concerned with broad and deep enquiry into the workings of nature; it is natural history in the best sense. Prior to the time of Darwin attempts to solve the kinetic problems of the organic world were hampered by anthropomorphism and narrowness of view, as well as by paucity of facts. But since then, owing to the immense influence of the works of that great naturalist, so much attention has been given to the fundamental problems of life that it is now possible to correlate many principles which describe not only the *fact* of evolution but many of the *factors* as well. And in this modern development wide observation has led so directly to extensive experiment that we may justly characterize the present period as an age of experimental zoology. Just as all the apparently disconnected studies of structural zoology deal with one matter—evolution—so in the sphere of experimental zoology all the radii converge upon the study of the factors and method of species transformation.

We can only mention some of the modern departments which have yielded brilliant results, such as cytology, experimental embryology, experimental fertilization and regeneration. But we may point out that the general problems in these various fields deal like the problem of evolution itself with an analysis of the internal and external influences that determine the final adult conditions of species. For example, the adult salamander possesses a specific structure, in a state of balance or adaptation, that is the final result of an evolution process up to the present time; this same specific condition is the goal of the changes through which the salamander's egg and embryo pass in development; it is the goal also that may be reached by even a portion of a divided salamander's egg; while finally it is the goal of the regenerative processes that enable a salamander from which a leg has been cut off to reproduce the missing part. Everything centers then about the question as to the origin of adult specific forms, which exhibit adaptation.

Realizing this, we may pass on immediately to consider how through the study of adaptation, Darwin was led to formulate his potent theories, which have been the basis for recent progress. As the other speakers upon biological sciences have already stated, the most striking feature of animals and plants is their adjustment to their vital conditions. An organism that seems so sufficient unto itself, so capable and independent, is nevertheless inextricably interlocked with its surroundings, for its very substance is composed of materials which with their endowments of energy have been wrested from the environment. An animal that is pressed upon by the substances of the outer world, that is played upon by various energies, and is attacked on all sides by innumerable foes, finds itself involved in a warfare that is tragically one-sided; and it must prevail over all its many foes or it must acknowledge defeat and pay the penalty for unconditional surrender, which is death—so stern and unyielding is that vast totality we individualize as the environment. The generalized biological formula, then, for the turmoil of nature is *adaptation* = *life*.

Here, then, is the heart of the mystery. How has this universal condition of adaptation been brought about? What have animals within them that might determine their greater or less efficiency? What external influences, if any, are capable of directing the efforts of living creatures to meet their enemies? How are modifications perpetuated when they have arisen? To many of these questions Darwin, Weismann, Mendel, De Vries and others have found answers, not complete or perfect, it is true, but they have relegated to the past the former reply that supernatural causes must be invoked to account for nature. Science is convinced that the study of nature's workings at the present time reveals natural factors which are competent to account for much of the wonderful process of evolution.

As every one knows, the works of Darwin inaugurated our recent era in biology. In 1858, Darwin and Wallace announced the doctrine of natural selection, and, in 1859, Darwin published the "Origin of Species," a book that has proved a veritable Magna Charta of intellectual liberties, for as no other single document before or since it has released the thoughts of men from the trammels of unreasoned conservatism and dogmatism. And its influence has been felt far beyond the borders of biological science—it has extended to the very confines of organized knowledge everywhere. But it is a mistaken popular notion, and one of the hardest to drive from the mind of the layman in science, that Darwin founded the doctrine of evolution by the book mentioned and those that followed. The fact of evolutionary descent had been established long before, while even some of the special points of Darwin's theories as to method had been anticipated. Had Darwin never lived, I believe that evolution would still be accepted and taught at the present day. But Darwin rendered two immortal services to science. During the twenty years that elapsed between the first conception of his theories and the date of their publication, he marshalled in orderly array all the biological data obtainable which proved the transformation of species, including the previously unrecognized body of evidence afforded by the domesticated animals. In the second place, in his doctrine of natural selection he presented for the first time a partial consistent program of nature's method of accomplishing evolution. Darwin did not believe that this explanation was final or even complete, whatever his opponents of the time or critics of the present might contend.

What, now, is the doctrine of natural selection, as Darwin propounded it? All animals vary; every individual differs from others of its kind, even from its closest kin and from its parents in some or many particulars and to different degrees. Whatever the causes, the fact of variation stands unquestioned. Some variations are of course due to direct environmental influence, and to these Buffon attributed an excessive importance; other deviations from the parental or average specific type are no doubt due to indirect effects of the environment, as Lamarck contended. But there are countless other variations that can not be so explained, some of them indeed appearing before an individual is subjected to the action of the environment, and these are the congenital variations due to some constitutional even if unknown causes. These seemed to Darwin to be the most important in evolution.

The second element of the doctrine is that over-production, or rather over-*re*production, is a universal characteristic of living things. The normal rate of multiplication is such that any given form of animal or plant would cumber the earth or fill the sea in a relatively brief period of time. We now know that a bacillus less than $1/_{5000}$ of an inch in length multiplies under normal conditions at a rate that would cause the offspring of a single individual to fill the ocean to the depth of a mile in five days. "Slow-breeding man," wrote Darwin, "has doubled in the past twenty-five years." But excessive multiplication is checked by the third part of the whole process, namely, the struggle for existence, that fierce unequal warfare waged by every individual with its inorganic surroundings, with other species of living things, and with others of its own kind. Indeed where members of the same species compete, the struggle often surpasses in ferocity the warfare with other organisms. Communal organisms only are in part exceptions, for in these the battle involves the clash of community with community more than it does the interests of the individuals of a single colony. To what, now, do these elemental processes lead, asks Darwin. Though all seek to maintain themselves, all can not possibly live when only a few can find sustenance or can escape their enemies. Naturally those which possess any advantage whatsoever, that vary ever so slightly in the direction of better adjustment would survive where their brethren perish. And this is nature's selective process, with its positive and negative aspects—the survival of the fittest and the elimination of the unfit. Now we can see why adaptation is a universal characteristic of species—there are no unadapted. If such there were, they have fallen long ago, and the world knows them no more. True it is that perfection is not attained by any creature, but it must establish a *modus vivendi* or it perishes. Thus, Darwin held, nature perfects species by dealing directly with favoring derivations that are mainly congenital, and so through these it selects the herditary factors that determine favorable variations.

In one fundamental respect the doctrine is incomplete, as it fails to explain the causes for the variations with which selection deals. It accounts for the perpetuation of favoring variations, but it does not account for their inception. Because of this defect, investigators reacted from the academic discussion of Darwin's original doctrine, and returned to deeper and wider study of heredity and variation with brilliant success. Some neo-Darwinians have endeavored to make the selective process an originative influence—notably Roux, and Weismann in his theory of germinal selection. Darwin himself added the subsidiary process of sexual selection, which regards the preference by one sex of characteristics of the opposite sex as a conserving influence. But while such attempts have failed, zoologists believe, to explain the whole method of evolution, much of the process has been demonstrated more and more clearly with further study. The laws of fluctuating variations have now been formulated with mathematical accuracy, through the employment of the statistical methods used earlier by anthropologists like Quetelet. The studies of Galton and Pearson, Boas, Weldon and Davenport have demonstrated that structural and physiological characters of men, of other animals, and of plants as well, vary according to the formulas of chance or error—a result they say that follows from the combined influence of innumerable and independent factors. Variation is a natural phenomenon of chance. Furthermore, the reality of the selective process has also been proved by statistical methods. Bumpus's English sparrows, Weldon's snails and crabs, and many other cases show that the individuals which depart widely from an average condition, or that are uncorrelated in their organization, are marked for destruction.

In brief, while natural selection has not been established as in any sense an originative process, it has been demonstrated, I believe, as a judicial process. For we may liken the many varied vital conditions to jurymen, before whom every organism must present itself for judgment; and a unanimous verdict of complete or at least partial approval must be rendered, or the organism must perish.

The phenomena of biological inheritance, however, have demanded the greater attention of Darwinian and post-Darwinian investigators. A complete statement of the whole of evolution must show how species maintain the same general characteristics through inheritance, how the type is held true with passing generations, and it must also show how new characters may enter into the heritage of any species to be transmitted as organisms transform in evolution.

The earliest naturalists had accepted the fact of inheritance as self-sufficient. The resemblance between parent and offspring did not demand an explanation any more than variation. When Buffon, however, added the element of species transformation, he held that external influences could bring about a directly responsive organic change, which he assumed was inherited. Lamarck developed the well-known view, previously advocated by Erasmus Darwin, that indirect responses to the environment could be fixed in inheritance as so-called "acquired characters," meaning by this phrase that such characters are acquisitions during the life-time of an individual as the effects of disuse or unusual use, or of new habits. Coming again to Darwin, we find that he endeavored to support Lamarck's doctrine and to supplement his doctrine of selection by adding the theory of pangenesis. According to this every cell of every tissue and organ of the body produces minute particles called gemmules, which partake of the characters of the cells that produce them. The gemmules were supposed to be transported throughout the entire body, and to congregate in the germ-cells, which would be in a sense minute editions of the body which bears them, and would so be capable of producing the same kind of a body. If true, this view would lead to the acceptance of Lamarck's or even Buffon's doctrine, for changes induced in any organ by other than congenital factors could be impressed upon the germ-cell, and would then be transported together with the original specific characters to future generations. Darwin was indeed a good Lamarckian.

But the researches of post-Darwinians, and especially those of the students of cellular phenomena, have demonstrated that such a view has no real basis in fact. Many naturalists, like Naegeli and Wiesner, were convinced that there was a specific substance concerned with hereditary qualities as in a larger way protoplasm is the physical basis of life. It remained for Weismann to identify this theoretical substance with a specific part of the cell, namely, the deeply-staining substance, or chromatin, contained in the nucleus of every cell. Bringing together the accumulating observations of the numerous cytologists of his time, and utilizing them for the development of his somewhat speculative theories, Weismann published in 1882 a volume called "The Germ-Plasm," which is an immortal foundation for the later work on inheritance. The essential principles of the germ-plasm theory are somewhat as follows: The chromatin of the nucleus contains the determinants of hereditary qualities. In reproduction, the male sex-cell, which is scarcely more than a minute mass of chromatin provided with a thin coat of protoplasm and a motile organ, fuses with the egg, and the nuclei of the two cells unite to form a double body, which contains equal contributions of chromatin from the two parental organisms. This gives the physical basis for paternal inheritance as well as for maternal inheritance, and it shows why they may be of the same or equivalent degree. When, now, the egg divides, at the first and later cleavages, the chromatin masses or chromosomes contained in the double nucleus are split lengthwise and the twin portions separate to go into the nuclei of the daughter cells. As the same process seems to hold for all the later divisions of the cleavage-cells whose products are destined to be the various tissue elements of the adult body, it follows that all tissue-cells would contain chromatin determinants derived equally from the male and female parents. As of course only the germ-cells of an adult organism pass on to form later generations, and as their content of chromatin is derived not from the sister-organs of the body but from the original fertilized egg, there is a direct stream of the germ-plasm which flows continuously from germ-cell to germ-cell through succeeding generations. This stream, be it noted, does not flow circuitously from egg to adult and then to new germ-cells, but it is direct and continuous, and apparently it can not pick up any of the body-changes of an acquired nature; indeed, it is doubtful whether such changes can reach the germ-cells at all, for the path is not traversed in that retrograde direction.

It must be clear, I am sure, that this theory supplements natural selection, as it describes the physical basis of inheritance, it demonstrates the efficiency of congenital or germ-plasmal factors of variation in contrast with the Lamarckian factors, and finally in the way that in the view of Weismann it accounts for the origin of variations as the result of the commingling of two differing parental streams of germ-plasm.

At first, for many reasons, Weismann's theories did not meet with general acceptance, but during recent years there has been a marked return to many of his positions, mainly as the result of further cytological discoveries, and of the formulation of Mendel's law and of De Vries's mutation theory. The first-named law was propounded by Gregor Mendel on the basis of extensive experiments upon plants conducted during many years, from 1860 on, in the obscurity of his monastery garden at Altbrünn, in Germany. It was rescued from oblivion by De Vries who found it buried in a mass of literature and brought it to light when he published his renowned mutation theory in 1901. Mendelian phenomena of inheritance, confirmed and extended by numerous workers with plants and animals, prove that in many cases portions of streams of germ-plasm that combine to form the hereditary content of organisms may retain their individuality during embryonic and later development, and that they may emerge in their original purity when the germ-cells destined to form a later generation undergo the preparatory processes called maturation. They demonstrate also the apparent chance nature of the phenomena of inheritance. I think the most striking and significant result in this field is the proof that a particular chromosome or chromatin mass determines a particular character of an adult organism, which is quite a different matter from the reference of all the hereditary characters to all of the chromatin. Professor Wilson has brought forward the convincing data showing that the complex character of sex in insects actually resides in or is determined by particular and definite masses of this wonderful basis of inheritance.

Mendel's principles also account in the most remarkable way for many previously obscure phenomena, such as reversion, and again, the case where a child resembles its grandparent more than either of its parents; these seem to be due, so to speak, to the rise to the surface of a hidden stream of germ-plasm that had flowed for one or many generations beneath its accompanying currents. I believe that the law is replacing more and more the laws of Galton and Pearson, formulated as statistical summaries of certain phenomena of human inheritance taken *en masse*. According to Galton's celebrated law of ancestral inheritance, the qualities of any organism are determined to the extent of a certain fraction by its two parents taken together as a mid-parent, that a smaller definite fraction is contributed by the grandparents taken together as a mid-grandparent, and so on to earlier generations. But Mendel's Law has far greater definiteness, it explains more accurately the cases of alternative inheritance, and it may be shown to hold for blended and mosaic inheritance as well.

De Vries's mutation theory has already been explained in an earlier address by Professor Richards. It is clearly not an alternative but a complementary theory to natural selection, the germ-plasm and Mendelian theories. Like these last, it emphasizes the importance of the congenital hereditary qualities contained in the germ-plasm, though unlike the Darwinian doctrine it shows that sometimes new forms may arise by sudden leaps and not necessarily by the slow and gradual accumulation of slight modifications or fluctuations. The mutants like any other variants must present themselves before the jury of environmental circumstances, which passes judgment upon their condition of adaptation, and they, too, must abide by the verdict that means life or death.

From what has been said of these post-Darwinian discoveries, the Lamarckian doctrine, which teaches that acquired non-congenital characters are transmitted, seems to be ruled out. I would not lead you to believe that the matter is settled. I would say only that the non-transmission of racial mutilations, negative breeding experiments upon mutilated rats and mice, the results of further study of supposedly transmitted immunity to poisons—that all these have led zoologists to render the verdict of "not proved." The future may bring to light positive evidence, and cases like Brown-Séquard's guinea-pigs, and results like those of MacDougal with plants and of Tower with beetles may lead us to alter the opinion stated. But as it stands now most investigators hold that there are strong general grounds for disbelief in the principle, and also that it lacks experimental proof.

The explanation of natural evolution given by Darwinism and the principles of Weismann, Mendel and De Vries, still fails to solve the mystery completely, and appeal has been made to other agencies, even to teleology and to "unknown" and "unknowable" causes as well as to circumstantial factors. A combination of Lamarckian and Darwinian factors has been proposed by Lloyd Morgan, Mark Baldwin and Professor Osborn, in the theory of organic selection. The theory of orthogenesis propounded by Naegeli and Eimer, now gaining much ground, holds that evolution takes place in direct lines of progressive modification, and is not the result of apparent chance. Of these and similar theories, all we can say is that if they are true, they are not so well-substantiated as the ones we have reviewed at greater length.

The task of experimental zoology is to work more extensively and deeply upon inheritance and variation, combining the methods and results of cellular biology, biometrics and experimental breeding. We may safely predict that great advances will be made during the next few years in analyzing the method of evolution; and that a few decades hence men will look back to the present time as a period of transition like the era of re-awakened interest and renewed investigation that followed the appearance of the "Origin of Species."

We must now state distinctly and fairly the present views of science regarding man's place in nature. Surely human evolution is a subject that falls within the scope of zoological investigation, unless indeed it can be shown that the human species is exempt from the control of those laws of nature that hold sway over the animate world elsewhere, unless something can be found which excludes man from the animal kingdom. Notwithstanding the most prolonged search not only by zoologists but as well by those who have been unfriendly to the doctrine of descent, the study of man and of men has revealed nothing essentially unique. What is known of the anatomy, development and fossil relations of man is summarized in the statement that he belongs to the genus and species *Homo sapiens,* placed with the apes and some other forms in the order primates because of agreement in certain peculiar details. The primates agree with the carnivora, rodents and many other orders in the characteristics of the class mammalia, which in turn is only a branch of the limb vertebrata or chordata, which also bears the avian, reptilian, amphibian and fish branches. And all the vertebrates including man agree with the varied groups of invertebrates in their cellular constitution and in the similar protoplasmic basis of life. As in these structural respects, so in physiological activities and in environmental relations the human species proves more surely with increased knowledge to be only one of the terms in the extensive series of animals. Indeed, the scientific monism of Haeckel and Clifford ventures to assert that man and all other living creatures are one with the mind-stuff of the inorganic world—and this, I believe, is only the logical extension of the genetic and mechanistic hypotheses. However this may be, science holds that human structure is animal structure, and that human lives are biological phenomena.

Man is structurally inferior in many respects to some of his zoological relatives—he is a degenerate, indeed, in many parts of the alimentary, muscular and skeletal systems—yet he finds in the higher development of his nervous system an advantage that offsets the weaknesses of his constitution elsewhere. He holds his supreme place by virtue only of superior and more effective control of his organization.

Behind their seeming structural differences, only one real distinction can be found to separate man from the apes—the higher development of the brain. The erect posture, the correlated modifications of skeletal and muscular structures, and apparently the powers of speech and reason, seem to be dependent upon the enlargement of this organ, which, so to speak, has pushed the face around under the brain-case. Therefore he who would be ὁ ἄνθρωπος—he who looks ahead—must needs stand erect in order to prevent his eyes from looking straight into the ground. But the most careful analysis has so far failed to detect any essential differences in either structural or functional respects between the human brain and the corresponding organs of the higher apes. In brief, then, differences in degree and not in kind or category seem to distinguish man from the apes—as far as science goes.

Moreover, the human body is a veritable museum of rare and interesting relics of antiquity—the useless vestiges and rudiments of structures that are more developed in other animals. The complete coat of hair of the embryo, the disappearing thirteenth rib, the ape-like and transitory clasping muscle of the new born infant's hand, the curvature of the lower limb and the hand-like foot of the embryo, these and scores of other characters are mutely eloquent witnesses to the past history of change that has brought man to his present place in nature. Embryology gives a vast amount of additional independent testimony. For like all embryo mammals and birds and reptiles, the human embryo possesses gill-slits, and fish-like heart and brain. Above all it begins life as a single cell. Zoology asks: What can these things mean, if they do *not* mean evolution and a common ancestry with other forms? The objection that no one has ever seen a one-celled organism evolve into a many-celled one, or into a fish or an ape, or into a man, the zoologist answers by placing upon the table the evidence that a single-cell, the human egg, actually does compass the whole history in becoming the almost inconceivably complex adult organism. The process *can* take place for it *does* take place. Paleontology also presents evidence relating to the history of our species, as the third support of the tripod upon which rests the doctrine of human evolution. While opinions differ with respect to the remains of man taken from the many caves and mounds of Europe and America, there is but one generally accepted view regarding the ape-man *Pithecanthropus* of the Javan rocks. The remains of this animal prove among other things that its brain was intermediate between the average ape brain and the average human brain, that the animal was indeed an ape-man and nothing else.

Science holds, furthermore, that natural factors alone have brought about human evolution. While it is true that the explanation is no more complete for this special instance than it is for animals in general, yet the human species is not exempt from the control of the known factors, like those which cause variation or govern inheritance. Indeed, some of the significant facts of heredity have been first made out in the human species. Can we doubt the reality of selection and the struggle for existence when scores perish annually in the conflict with extreme degrees of temperature and other environmental forces, when as a result of the unceasing combat with bacterial enemies alone the casualties on the human side number in our country more than a hundred thousand annually?

To the zoologist it seems strange that there is so much opposition to the doctrine of human evolution. In truth he finds this to be proportional to misunderstanding of the facts, for when the evidence is produced—Pelion piled on Ossa—any lingering doubts the observer might have are crushed by an irresistible weight of testimony. After all, our kind is but one of the many hundreds of thousands of living species; and viewing the matter from the calm, impersonal standpoint of scientific study, the fact that he is himself a human being does not distort the investigator's vision, for his perspective is corrected and rectified by the instruments of scientific method. He finds no difficulty in accepting human evolution as a scientific fact—that is, true as far as science goes.

In extending its broad comparative studies into the field of complex and intricate human nature, zoology touches numerous other sciences that might seem at first sight to be entirely independent, or at the most only casually connected with it. I shall venture to point out where analysis within the field of zoology has produced results which have a high and immediate value for students of anthropology, psychology, sociology and ethics.

When they deal with the evolution of the human species from prehuman animals, the anthropologist and the zoologist are brought by their similar interest upon common ground; and when they pass on to explore the field of human diversity where lie the complex problems of racial evolution, they are still fellow-workers, for in the case of physical anthropology of human races at least the methods are the same which are employed in zoology generally. Of course it would be absurd for any one to contend that all the problems of anthropology are strictly zoological questions; to qualify here an investigator must be familiar with linguistics, racial customs and beliefs, and many subjects that are as such apparently outside the limits of zoology. But unless a sharp line is to be drawn between the slow origin by evolution of the human species and the later history of this species, the comparative and genetic methods of analysis which render the earlier process intelligible can scarcely fail to be of service in dealing with the latter. The great danger, which the zoologist himself clearly sees, arises from a tendency to ignore the detail in formulating the general, to oversimplify the problems of the more recent history. For human conscious elements are so complex and plastic that the problems of racial evolution are rendered far more intricate than the broad zoological analysis of the origin of man as a species.

Psychology, in the second place, is a subject that is related to zoology by the closest of ties, the bond of union being again the common human element. To be sure, the zoologist finds enough in his own field to occupy him fully, but the compaative study of nervous systems, and of the reflex, instinctive, intelligent and reasoned responses of animals brings him inevitably to consider the relation of human mentality and consciousness to the other terms of the animal series. Dealing strictly as a zoologist with animals and their lives, the investigator learns that the machine-like regularity of reflex and instinctive activities is correlated, broadly speaking, with simple nervous organization; that the plasticity of intelligent response is not gained until the physical basis becomes far more complicated; and finally that reason and consciousness are in some way bound up with the higher development of the nerve-centers or ganglia that make up the brain. So the zoologist is inclined to believe that the comparative series of mental grades which culminates in the consciousness, or rather the self-consciousness, of the adult human organism, and the series of developmental stages through which the human mental structure passes during infancy and childhood, indicate an evolution in time of the psychic being of man. Whatever may be the outcome of further study, Romanes, Lloyd Morgan, Forel and Thorndike, among those of modern times, have demonstrated that the genetic methods of zoology are useful instruments for the psychologist, who, I believe, is becoming more and more a student of zoological materials as he realizes the advantage of studying the simpler psychic phenomena of animals lower than man.

In venturing to speak of the relation of zoology to sociology and ethics, I am well aware that I shall be charged with straying beyond the confines of my subject. But if the student of lower forms should find well-defined principles of biological association and principles of animal conduct, it is not only his privilege, it is in a sense his duty as well to bring these to the consideration of the students of human social and ethical relations. Unless in these matters there has been a break in the continuity of evolution, the simpler relations to be observed in lower animals must surely possess a profound interest—and perhaps more.

In a true sense, any of the many-celled animals is a community, whose constituent members are the differentiated tissue-cells, which have undertaken the various tasks of digestion, contraction, sensation and the rest. By far the majority of animals are cell-communities of this nature. Considering these as individuals, though of a secondary order, we find some communities made up of several animals which have banded together for mutual support and defense, giving us as in the wolf-pack a counterpart of the lowest associations of savage men. But among insects especially we find colonies of numerous multicellular individuals which may be so rigidly specialized for the performance of certain tasks that we can not avoid the use of terms applied to civilized human groups in describing their differentiation and division of labor. Some colonies of bees comprise queens and drones and only one kind of sterile workers, though when newly hatched these last serve as guards and nurses, taking the field as foragers for pollen and honey only later in life. In various ant-colonies we shall find workers who serve as herdsmen, devoting their time to the care of the ant-cattle or aphids; again there are masons, and gardeners, and carpenters, and soldiers of various ranks, while in the honey-ant some individuals may serve as living receptacles for the tribal stores of food. Each kind undertakes one of the tasks that are vital for the life of the community as a whole. Instinctive and unreasoned their activities may be, and undoubtedly are, but the economic and social relations of the component members of the colony are strikingly analogous to certain fundamental phenomena of human societies. But still more wonderful are the cases that may be found among hornets and wasps. A fertile female over-winters and places her first-laid eggs in the chambers of a simple nest that she constructs herself. When the young of the first brood hatch, she provides them with food, enlarges the nest, and continues the task of egg-laying, while her first offspring relieve her of her former duties as they become able. They enlarge the nest, they care for their younger kin as they hatch, they forage abroad for the food-supplies for the colony. And so the community that begins life in the early spring with a solitary animal advances during the passing weeks to a degree of complexity that is truly astounding. As an epitome of insect social evolution it gives in a few weeks a review of the process that in other forms of social insects with stable colonies, or in the analogous human history, has demanded centuries of time.

As we review these different kinds of individuals—the one-celled animal, the many-celled creature and the community—we see that each one must obey certain rules of nature. It must preserve itself, it must perpetuate its kind, and, if it be a member of a higher community, it must act in the interests of others and of the whole group. Do we not find, then, biological definitions of right, and evil, and duty to others as well as to self? Do we not see why altruism has grown out of egoism as communities have evolved at the behest of nature?

But still, facts like these are purely zoological facts. To be well within his rights, the zoologist should perhaps only suggest their usefulness for the analysis of human social relations and obligations. It is for the sociologist and the student of comparative ethics to employ and apply them according to the principles of the genetic method, should they see fit to do so.

In closing, may I say a few words regarding the attitude of the zoologist toward his problems and his results. He may maintain this attitude because of a certain temperament which leads him and his fellows to enter the field of science as investigators. While this may be true, it is also true, I believe, that the subjects of their study, the principles they may discern in nature's order, and their methods of analysis have a profound reflex effect upon not only the contents of their minds but upon their mental machinery as well. The zoologist, like his fellow men of science, learns early that he must adopt an impersonal attitude, for emotion and purely human interest are disturbing elements that prevent him from attaining the purpose of the investigator—which is, to ascertain and verify facts, to classify them logically, so as to derive from them the summaries which like so much "conceptual short-hand" are available for others as well as himself. Science is "organized knowledge," as Pearson defines it; "organized common sense" in Huxley's phrase; and like other men of science the zoologist learns to view his great common-sensible principles like the doctrine of descent, not as absolute eternal verities, but only as summaries up to date, as working programs, to employ Professor Wilson's concise phrase. This *may* be pragmatism; it is certainly science.

But surely this does not mean that principles like the one mentioned are so many gratuitous assumptions. Like the principle of gravitation and the law of the conservation of energy, zoological laws have the strength and approximate finality of all the wide range of facts that they summarize. And these are many—a vast store of detail and generalization accumulated during decades and centuries by those who have sought upon the mountains or in the abysses of the seas for new knowledge, but countless students who have spent their lives in the field and in the laboratory in the endeavor to pierce still further with trained insight into the mysteries of nature. And these are their results.

No one realizes more than the zoologist that his knowledge is incomplete. No one can see more clearly than he that his intellect evolves, like the great sweeping tide of things and events—the nature he studies and of which he is but a conscious atom. The investigator soon learns to withhold final judgment, agreeing with Clifford that the primary conditions for intellectual development are the plasticity and openness of mind that dogmatism and finality destroys. The end of zoology can not be until the end of all knowledge.

Conscious, then, of the impossibility of reaching absolutely final knowledge, why does the investigator continue to search the world of nature as he does? Because of that ingrained and insatiable human curiosity to learn, because of the human discontent with the attained. Antæus-like, every fresh contact with the world of law and order infuses new energy into his veins for further endeavor. "Und es treibt und reisst ihn fort, rastlos fort . . ." not, it is true, in the wandering blindness of Schiller's huntsman, for his human vision is aided by the instrument of scientific method with which he can *almost* perceive the infinitely great and the infinitely small.

Glorying in the great achievements of his science, reveling like the mathematician in the ordered assemblage of related and organized knowledge, the student of zoology joins his fellows yet again for a renewed attack upon the distant ramparts of the unknown, deriving courage and inspiration from the motto: *Ignoramus, in hoc signo laboremus.*

EXPERIMENTS WITH THE LANGLEY AERODROME[1]

By Dr. S. P. LANGLEY
SECRETARY OF THE SMITHSONIAN INSTITUTION

THE experiments undertaken by the Smithsonian Institution upon an aerodrome, or flying machine, capable of carrying a man have been suspended from lack of funds to repair defects in the launching apparatus without the machine ever having been in the air at all. As these experiments have been popularly, and of late repeatedly, represented as having failed, on the contrary, because the aerodrome could not sustain itself in the air I have decided to give this brief though late account, which may be accepted as the first authoritative statement of them.

It will be remembered that in 1896 wholly successful flights of between one half and one mile by large steam-driven models, unsupported except by the mechanical effects of steam engines, had been made by me. In all these the machine was first launched into the air from "ways," somewhat as a ship is launched into the water, the machine resting on a car that ran forward on these ways, which fell down at the extremity of the car's motion, releasing the aerodrome for its free flight. I mention these details because they are essential to an understanding of what follows, and partly because their success led me to undertake the experiments on a much larger scale I now describe.

In the early part of 1898 a board, composed of officers of the army and navy, was appointed to investigate these past experiments with a view to determining just what had been accomplished and what the possibilities were of developing a large-size man-carrying machine for war purposes. The report of this board being favorable, the Board of Ordnance and Fortification of the War Department decided to take up the matter, and I having agreed to give without compensation what time I could spare from official duties, the board allotted $50,000 for the development, construction and test of a large aerodrome, half of which sum was to be available immediately and the remainder when required. The whole matter had previously been laid before the board of regents of the Smithsonian Institution, who had authorized me to

[1] Dr. Langley's pioneer experiments in aerial navigation are of such contemporary interest that we reproduce this article, written shortly before his death, and printed in the Annual Report of the Smithsonian Institution for 1904.

take up the work and to use in connection with it such facilities of the institution as were available.

Before consenting to undertake the construction of this large machine, I had fully appreciated that, owing to theoretical considerations, into which I do not enter, it would need to be relatively lighter than the smaller one; and later it was so constructed, each foot of sustaining surface in the large machine carrying nearly the same weight as each foot in the model. The difficulties subsequently experienced with the larger machine were, then, due not to this cause, but to practical obstacles connected with the launching, and the like.

I had also fully appreciated the fact that one of the chief difficulties in its construction would lie in the procuring of a suitable engine of sufficient power and, at the same time, one which was light enough. (The models had been driven by steam engines whose water supply weighed too much for very long flights.) The construction of the steam engine is well understood, but now it would become necessary to replace this by gas engines, which for this purpose involve novel difficulties. I resolved not to attempt the task of constructing the engine myself, and had accordingly entered into negotiations with the best engine builders in this country, and after long delay had finally secured a contract with a builder who, of all persons engaged in such work, seemed most likely to achieve success. It was only after this contract for the engine had been signed that I felt willing to formally undertake the work of building the aerodrome.

The contract with the engine builder called for an engine developing 12 brake horsepower, and weighing not more than 100 pounds, including cooling water and all other accessories, and with the proviso that a second engine, exactly like this first one, would be furnished on the same terms. The first engine was to be delivered before the close of February, 1899, and the frame of the aerodrome with sustaining surfaces, propellers, shafting, rudders, etc., was immediately planned, and now that the engine was believed to be secured, their actual construction was pushed with the utmost speed. The previous experiments with steam-driven models, which had been so successful, had been conducted over the water, using a small house-boat having a cabin for storing the machine, appliances and tools, on top of which was mounted a track and car for use in launching. As full success in launching these working models had been achieved after several years spent in devising, testing and improving this plan, I decided to follow the same method with the large machine, and accordingly designed and had built a house-boat, in which the machine could not only be stored, but which would also furnish space for workshops, and on the top of which was mounted a turntable and track for use in launching from whatever direction the wind might come.

Everything connected with the work was expedited as much as possible with the expectation of being able to have the first trial flight before the close of 1899, and time and money had been spent on the aerodrome, which was ready, except for its engine, when the time for the delivery of this arrived. But now the builder proved unable to complete his contract, and, after months of delay, it was necessary to decrease the force at work on the machine proper and its launching appliances until some assurance could be had of the final success of the engine. During the spring and summer of 1899, while these delays were being experienced in procuring suitable engines, former experiments on superposed wing surfaces were continued, time was found for overhauling the two steam-driven models which had been used in 1896, and the small house boat was rebuilt so that further tests of these small machines might be made in order to study the effect of various changes in the balancing and the steering, equilibrium preserving and sustaining appliances, and the months of June, July and a portion of August were spent in actual tests of these machines in free flight.

A new launching apparatus following the general plan of the former overhead one, but with the track underneath it, was built for the models, and it was used most successfully in these experiments, more than a dozen flights in succession being made with it, while in every case it worked without delay or accident. As soon as these tests with the models on this underneath launching apparatus were completed, that for the large machine was built as an exact duplicate, except for the enlargement, and with some natural confidence that what had worked so perfectly on a small scale would work fairly on a large one.

It was recognized from the very beginning that it would be desirable in a large machine to use "superposed" sustaining surfaces (that is, with one wing above another) on account of their superiority so far as the relation of strength to weight is concerned, and from their independence of guy wiring; and two sets of superposed sustaining surfaces of different patterns were built and experimented with in the early tests. These surfaces proved, on the whole, inferior in lifting power, though among compensating advantages are the strength of a "bridge" construction which dispenses with guy wires coming up from below, which, in fact, later were the cause of disaster in the launching.

It was finally decided to follow what experiment had shown to be successful, and to construct the sustaining surfaces for the large machine after the "single-tier" plan. This proved to be no easy task, since in the construction of the surfaces for the small machines the main and cross ribs of the framework had been made solid, and, after steaming, bent and dried to the proper curvature, while it was obvious that this plan could not be followed in the large surfaces on account of the necessity, already alluded to, of making them relatively lighter than the small ones, which were already very light. After the most painstaking construction, and tests of various sizes and thicknesses of hollow square, hollow round, I-beam, channel, and many other types of ribs, I finally devised a type which consisted of a hollow box form, having its sides of tapering thickness, with the thickest part at the point midway between contiguous sides and with small partitions placed inside every few inches in somewhat the same way that nature places them in the bamboo. These various parts of the rib (corresponding to the quill in a wing) were then glued and clamped together, and after drying were reduced to the proper dimensions and the ribs covered with several coats of a special marine varnish, which it had been found protected the glued joints from softening, even when they were immersed in water for twenty-four hours.

Comparative measurements were made between these large cross ribs, 11 feet long, and a large quill from the wing of a harpy eagle, which is probably one of the greatest wonders that nature has produced in the way of strength for weight. These measurements showed that the large, 11-foot ribs ("quills") for the sustaining surfaces of the large machine were equally as strong, weight for weight, as the quill of the eagle; but much time was consumed in various constructions and tests before such a result was finally obtained.

During this time a model of the large machine, one fourth of its linear dimensions, was constructed, and a second contract was made for an engine for it. The delay with the large engine was repeated with the small one, and in the spring of 1900 it was found that both contract engines were failures for the purpose for which they were intended, as neither one developed half of the power required for the allotted weight.

I accordingly again searched all over this country, and, finally, accompanied by an engineer (Mr. Manly), whose services I had engaged, went to Europe, and there personally visited large builders of engines for automobiles, and attempted to get them to undertake the construction of such an engine as was required. This search, however, was fruitless, as all of the foreign builders, as well as those of this country, believed it impossible to construct an engine of the necessary power and as light as I required (less than 10 pounds to the horsepower without fuel or water). I was, therefore, forced to return to this country and to consent most reluctantly, even at this late date, to have the work of constructing suitable engines undertaken in the shops of the Smithsonian Institution, since, as I have explained, the aerodrome frame and wings were already constructed. This work upon the engines began here in August, 1900, in the immediate care of Mr. Manly. These engines were to be of nearly double the power first estimated and of little more weight, but this increased power and the strain caused by it demanded a renewal of the frame as first built, in a stronger and consequently in a heavier form, and the following sixteen months were spent in such a reconstruction simultaneously with the work on the engines.

The flying weight of the machine complete, with that of the aeronaut, was 830 pounds; its sustaining surface, 1,040 square feet. It, therefore, was provided with slightly greater sustaining surface and materially greater relative horsepower than the model subsequently described which flew successfully. The brake horsepower of the engine was 52; the engine itself, without cooling water, or fuel, weighed approximately 1 kilogram to the horsepower. The entire power plant, including cooling water, carburetor, battery, etc., weighed materially less than 5 pounds to the horsepower. Engines for both the large machine and the quarter-size model were completed before the close of 1901, and they were immediately put in their respective frames and tests of them and their power-transmission appliances were begun.

It is well here to call attention to the fact that although an engine may develop sufficent power for the allotted weight, yet it is not at all certain that it will be suitable for use on a machine which is necessarily as light as one for traversing the air, for it would be impossible to use, for instance, a single cylinder gasoline engine in a flying machine unless it had connected to it prohibitively heavy flywheels. These facts being recognized, the engines built in the Smithsonian shops were provided with five cylinders, and it was found upon test that the turning effect received from them was most uniform, and that, by suitable balancing of rotating and reciprocating parts, they could be made to work so that there was practically no vibration, even when used in the very light frames of the aerodromes.

The engine is not all the apparatus connected with the development and delivery of power, for obviously there must be shafts, bearings, and in the present case there were also gars; and all of these parts must necessarily be phenomenally light, while all of the materials must be capable of withstanding repeated and constant strains far beyond their elastic limit. It is also evident to any one having familiarity with such constructions that it is most difficult to keep the various bearings, shafts, gears, etc., in proper alignment without adding excessive weight, and also that when these various parts once get out of alignment when subject to strain, the disasters which are caused render them unfit for further use.

The engines themselves were successfully completed before the close of 1901, and were of much more power than those originally designed; but nearly a year and a half had been spent not only in their completion, but in properly coordinating the various parts of the frame carrying them, repairing the various breakages, assembling, dismounting and reassembling the various parts of the appliances, and in general rebuilding the frame and appurtenances to correspond in strength to the new engines.

There are innumerable other details, for the whole question is one of details. I may, however, particularly mention the carburetors, which form an essential part of every gas engine, and such giving fair satisfaction for use in automobiles were on the market at the time, yet all of them failed to properly generate gas when used in the tests of the engine working in the aerodrome frame, chiefly because of the fact that the movement of the engine in this light frame must be constant and regular or the transmission appliances are certain of distortion. It was, therefore, necessary to devise carburetors for the aerodrome engines which would meet the required conditions, and more than half a dozen were constructed which were in advance of anything then on the market, and yet were not good enough to use in the aerodrome, before a satisfactory one was made. These experiments were made in the shop, but with an imitation of all the disturbing influences which would be met with in the actual use of the machine in the air, so as to make certain, as far as possible, that the first test of the machine in free flight would not be marred by mishaps or unseen contingencies in connection with the generation and use of power.

It is impossible for any one who has not had experience with such matters to appreciate the great amount of delay which experience has shown is to be expected in such experiments. Only in the spring of 1903, and after two unforeseen years of assiduous labor, were these new engines and their appurtenances, weighing altogether less than 5 pounds to the horsepower and far lighter than any known to be then existing, so coordinated and adjusted that successive shop tests could be made without causing injury to the frame, its bearings, shafts or propellers.

And now everything seemed to be as nearly ready for an experiment as could be, until the aerodrome was at the location at which the experiments were to take place. The large machine and its quarter-size counterpart were accordingly placed on board the large house boat, which had been completed some time before and had been kept in Washington as an auxiliary shop for use in the construction work, and the whole outfit was towed to a point in the Potomac River, here three miles wide, directly opposite Widewater, Va., and about forty miles below Washington and midway between the Maryland and Virginia shores, where the boat was made fast to moorings which had previously been placed in readiness for it

Although extreme delays had already occurred, yet they were not so trying as the ones which began immediately after the work was thus transferred to the lower Potomac.

The object in constructing the quarter-size counterpart of the large machine was to duplicate in it the balancing and relative proportions of power, surface, etc., that had been arranged in the large one, so that a test of it might be made which would determine whether the large machine should be tried as arranged or the balancing and other arrangements modified. The launching apparatus, which had proved so eminently successful with the original steam-driven models in 1896, was considered a thing so well tested that it had, as I have stated, been duplicated on a suitable scale for use with the large aerodrome, and it was felt that if this apparatus were exactly similar to the smaller one it would be the one appliance least likely to mar the experiments.

In order to test the quarter-size model it was necessary to remove its launching track from the top of the small house boat and place it upon the deck of the large boat, in order to have all the work go on at one place, as it was impossible, on account of its unseaworthiness, to moor the small house boat in the middle of the river.

While this transfer of the launching apparatus from the small boat to the large one was being made, the changed atmospheric conditions incident to a large body of water over which thick fogs hung a great portion of the time, from those of a well-protected shop on the land, began to manifest themselves in such ways as the rusting of the metal parts and fittings, and the consequent disarrangement of the adjustment of the necessarily very accurate pieces of apparatus connected with the ignition system of the engine. These difficulties might have partly been anticipated, but there were others concerning which the cause of the deterioration and disarrangement of certain parts and adjustments was not immediately detected, and consequently when short preliminary shop tests of the small machine were attempted just prior to launching it, it was found that the apparatus did not work properly, necessitating repairs and new constructions and consequent delay. Although the large house boat with the entire outfit had been moved down the river on July 14, 1903, it was not until the eighth of August that the test of the quarter-size model was made, and all of this delay was directly due to changed atmospheric conditions incident to the change in locality. This test of the model in actual flight was made on the eighth of August, 1903, when it worked most satisfactorily, the launching apparatus, as always heretofore, performing perfectly, while the model, being launched directly into the face of the wind, flew directly ahead on an even keel. The balancing proved to be perfect, and the power, supporting surface, guiding and equilibrium-preserving effects of the rudder also. The weight of the model was 58 pounds, its sustaining surface 66 square feet, and the horsepower from $2\frac{1}{2}$ to 3.

This was the first time in history, so far as I know, that a successful flight of a mechanically sustained flying machine was made in public.

The flight was not as long as had been expected, as it was found afterwards that one of the workmen, in his zeal to insure an especially good one, had overfilled the gasoline tank, which would otherwise have enabled a flight several times as long. However, as such a flight would have given absolutely no more data than the short one did, and as the delays in getting ready for testing the large machine had already far exceeded what was expected, it was thought best not to make any more tests with the small one, as all of the data which were desired had been procured, and it was accordingly stored away and every energy immediately concentrated in getting the large machine ready for its first test, which at that time seemed only a few days away.

During all these delays it may be remarked that we necessarily resided near the house boat, and therefore in a region of malaria, from whose attacks a portion of us suffered.

I have spoken of the serious delays in the test of the small machine caused by changed atmospheric conditions, but they proved to be almost negligible compared with what was later experienced with the large one. I have also alluded to the fact that the necessarily light ribs of the large sustaining wing surfaces were covered with several coats of a special marine varnish which many tests had shown enabled the glue to withstand submersion in water for more than twenty-four hours without being affected. This water test was made with a view to guarding against the joints of the ribs being softened when the machine came down into the water, as it was planned for it to do at the close of its flight, and these submersions had apparently shown that no trouble need be anticipated from the effects of the sustaining surfaces getting wet. It is an instance of the unpredictable delays which present themselves, that when preparations had been begun for the immediate trial of the large machine, already down the river, it was found that every one of the cross ribs had been rendered almost useless by the damp, though under shelter. As it would take months to build new ones, a temporary means of repairing them was used. There were other delays too numerous to mention, but chiefly incident to working over the water, some of the principal of which were due to storms dragging the house boat from its moorings and destroying auxiliary apparatus, such as launches, boats, rafts, etc., to say nothing of the time consumed in bringing workmen to and from the scene of the experiments. The propellers were even found to break under the strain of the actual engines in the open, though they had not done so in the shop, and this is mentioned as another instance of the numerous causes of trying delay which it was impossible to foresee.

Finally, however, on the 3d of September, everything seemed to be in readiness for the experiments, and the large aerodrome was accordingly placed in position and all orders given and arrangements made for a test that day. After stationing the various tugs, launches, etc., at their predetermined positions so that they might render any assistance necessary to the engineer or the aerodrome, in case it came down in the water at a point distant from the house boat, and after the photographers, with special telephoto cameras, had been stationed on the shore in order that photographs with their trigonometrical data might be obtained, from which speed, distance, etc., might be later determined, and when every one was anxiously expecting the experiment, a delay occurred from one of the hardly predictable causes just mentioned in connection with the weather. An attempt was made to start the engine so that it might be running at its proper rate when the aerodrome was launched into free air after leaving the track, but the dry batteries used for sparking the engine, together with the entire lot of several dozen which were on hand as a reserve, had become useless from the dampness.

I have merely instanced some of these causes of failure when everything was apparently ready for the expected test, but only one who was on the spot and who had interest in the outcome could appreciate trials of this sort, and the delays of waiting for weather suitable for experiments.

It was found that every storm which came anywhere in the vicinity, immediately selected the river as its route of travel, and although a ten-mile wind on the land would not be an insurmountable obstacle during an experiment, yet the same wind on the river rendered it impossible to maintain the large house boat on an even keel and free from pitching and tossing long enough to make a test.

While speaking of the difficulties imposed by the weather, it should also be understood that to take the aerodrome in parts from under the shelter of the roof and assemble and mount it upon the upper works was a task requiring four or five hours, and that during this time a change in the weather was altogether likely to occur, and did repeatedly occur, sufficient to render the experiment impossible. Experience has shown, then, that the aerodrome should be sheltered by a building, in which it shall be at all times ready for immediate launching. During all the delay resulting from this and other causes—since it was never known on what day the experiment might take place—a great expense for tug boats waiting at a distance of forty miles from the city, was incurred, and this was a part of the continuous drain on the pecuniary resources, which proved ultimately more fatal than any mishap to the apparatus itself.

Following the 3d of September, and after procuring new batteries, short preliminary tests inside the boat were made in order to make sure that there would be no difficulty in the running of the engine the next time a fair opportunity arrived for making a test of the machine in free flight. Something of the same troubles which had

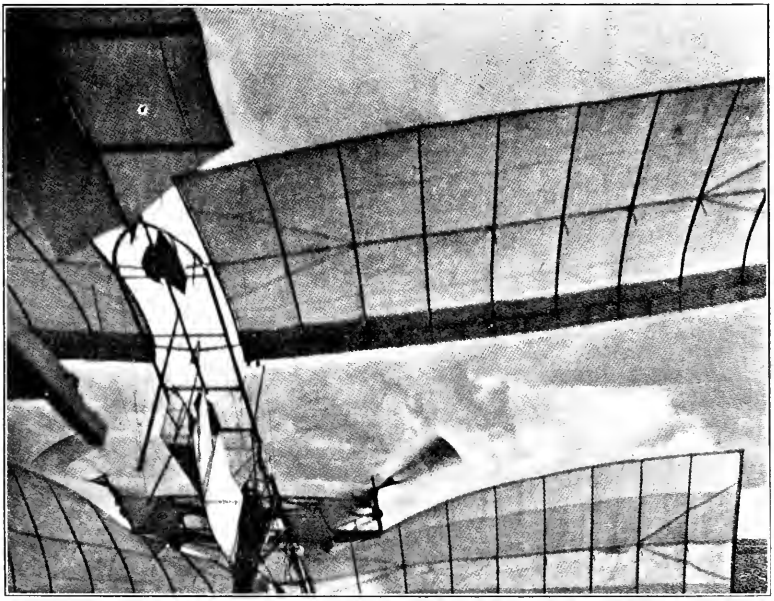


FIG. 1. INSTANTANEOUS PHOTOGRAPH OF THE LAUNCH OF OCTOBER 7, 1903.

been met with in the disarrangement of the adjustments of the small engine was experienced in the large one, although they occurred in such a different way that they were not detected until they had caused damage in the tests, and these disarrangements were responsible for broken propellers, twisted shafts, crushed bearings, distorted framework, etc., which were not finally overcome until the first of October. After again getting everything in apparent readiness, there then ensued a period of waiting on the weather until the seventh of October (1903), when it became sufficiently quiet for a test, which I was now beginning to fear could not be made before the following season. In this, the first test, the engineer took his seat, the engine started with ease and was working without vibration at its full power of over fifty horse, and the word being given to launch the machine, the car was released and the aerodrome sped along the track. Just as the machine left the track, those who were watching it, among whom were two representatives of the Board of Ordnance,[2] noticed that the machine was jerked violently down at the front (being caught, as it subsequently appeared, by the falling ways),[3] and under the full power of its engine was pulled into the water, carrying with it its engineer. When the aerodrome rose to the surface it was found that, while the front sustaining surfaces had been broken by their impact with the water, yet the rear ones were comparatively uninjured. As soon as a full examination of the launching mechanism had been made, it was found that the front portion of the machine had caught on the launching car, and that the guy post, to which were fastened the guy wires which are the main strength of the front surfaces, had been bent to a fatal extent.

The machine, then, had never been free in the air, but had been pulled down as stated.

The disaster just briefly described had indefinitely postponed the test, but this was not all. As has been said before, the weather had become very cold, and the so-called equinoctial storms being near, it was decided to remove the house boat at the earliest time possible, but before it could be done a storm came up and swept away all the launches, boats, rafts, etc., and in doing so completely demolished the greater part of them, so that when the house boat was finally removed to Washington, on the fifteenth of October, these appurtenances had to be replaced. It is necessary to remember that these long series of delays worked other than mere scientific difficulties, for a more important and more vital one was the exhaustion of the financial means for the work.

Immediately upon getting the boat to Washington the labor of constructing new sustaining surfaces was begun, and they were completed about the close of November. It was proposed to make a second attempt near the city, though in the meantime the ice had formed in the river. However, on the eighth of December, 1903, the atmosphere became very quiet shortly before noon and an immediate attempt was made at Arsenal Point, quite near Washington, though the site was unfavorable. Shortly after arriving at the selected point everything

[2] Major Macomb, of the Board of Ordnance, states in his report to the board, that "the trial was unsuccessful because the front guy post caught in its support on the launching car and was not released in time to give free flight, as was intended, but, on the contrary, caused the front of the machine to be dragged downward, bending the guy post and making the machine plunge into the water about 50 yards in front of the house boat."

[3] This instantaneous photograph, taken from the boat itself and hitherto unpublished, shows the aerodrome in motion before it had actually cleared the house boat. On the left is seen a portion of a beam, being a part of the falling ways in which the front wing was caught, while the front wing itself is seen twisted, showing that the accident was in progress before the aerodrome was free to fly.

was in readiness for the test. In the meantime the wind had arisen and darkness was fast approaching, but as the funds for continuing the work were exhausted, rendering it impossible to wait until spring for more suitable weather for making a test, it was decided to go on with it if possible This time there were on hand to witness the test the writer, members of the Board of Ordnance, and a few other guests, to say nothing of the hundreds of spectators who were waiting on the various wharves and shores. It was found impossible to moor the boat without a delay which would mean that no test could be made on account of darkness, so that it was held as well as possible by a tug, and kept with the aerodrome pointing directly into the wind, though the tide, which was running very strong, and the wind, which was blowing ten miles an hour, were together causing much difficulty. The engine being started and working most satisfactorily, the order was given by the engineer to release the machine, but just as it was leaving the track another disaster, again due to the launching ways, occurred.[4] This time the rear of the machine, in some way still unexplained, was caught by a portion of the launching car, which caused the rear sustaining surfaces to break, leaving the rear entirely without support, and it came down almost vertically into the water. Darkness had come before the engineer, who had been in extreme danger, could aid in the recovery of the aerodrome, the boat and machine had drifted apart, and one of the tugs, in its zeal to render assistance, had fastened a rope to the frame of the machine in the reverse position from what it should have been attached and had broken the frame entirely in two. While the injury which had thus been caused seemed almost irreparable to one not acquainted with the work, yet it was found upon close examination that only a small amount of labor would be necessary in order to repair the frame, the engine itself being entirely uninjured. Had this accident occurred at an earlier period, when there were funds available for continuing the experiments, it would not have been so serious, for many accidents in shop tests had occurred which, while unknown to the general public, had yet caused greater damage and required more time for repair than in the present case. But the funds for continuing the work were exhausted, and it being found impossible to immediately secure others for continuing it, it was found necessary to discontinue the experiments for the present, though I decided to use, from a private fund, the small amount of money

[4] Major Macomb again states in his official report to the board: "The launching car was released at 4:45 P.M. . . . The car was set in motion and the propellers revolved rapidly, the engine working perfectly, but there was something wrong with the launching. The rear guy post seemed to drag, bringing the rudder down on the launching ways, and a crashing, rending sound, followed by the collapse of the rear wings, showed that the machine had been wrecked in the launching; just how it was impossible to see."

necessary to repair the frame so that it itself, together with its engine, which was entirely uninjured, might be available for further use if it should later prove possible, and that they themselves might be in proper condition to attest to what they really represent as an engineering achievement.

Entirely erroneous impressions have been given by the account of these experiments in the public press, from which they have been judged, even by experts; the impression being that the machine could not sustain itself in flight. It seems proper, then, to emphasize and to reiterate, with a view to what has just been said, that the machine has never had a chance to fly at all, but that the failure occurred on its launching ways; and the question of its ability to fly is consequently, as yet, an untried one.

There have, then, been no failures as far as the actual test of the flying capacity of the machine is concerned, for it has never been free in the air at all. The failure of the financial means for continuing these expensive experiments has left the question of their result where it stood before they were undertaken, except that it has been demonstrated that engines can be built, as they have been, of little over one half the weight that was assigned as the possible minimum by the best builders of France and Germany; that the frame can be made strong enough to carry these engines, and that, so far as any possible prevision can extend, another flight would be successful if the launching were successful; for in this, and in this alone, as far as is known, all the trouble has come.

The experiments have also given necessary information about this launching. They have shown that the method which succeeded perfectly on a smaller scale is insufficient on a larger one, and they have indicated that it is desirable that the launching should take place nearer the surface of the water, either from a track upon the shore or from a house boat large enough to enable the apparatus to be launched at any time with the wings extended and perhaps with wings independent of support from guys. But the construction of this new launching apparatus would involve further considerable expenditures that there are no present means to meet; and this, and this alone, is the cause of their apparent failure.

Failure in the aerodrome itself or its engines there has been none; and it is believed that it is at the moment of success, and when the engineering problems have been solved, that a lack of means has prevented a continuance of the work.

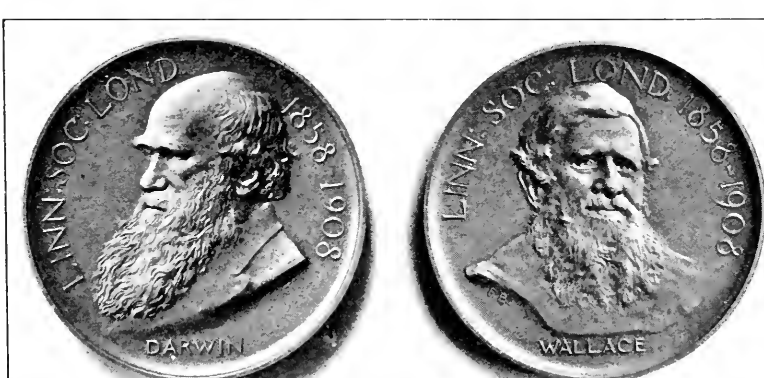
THE PROGRESS OF SCIENCE

THE FIFTIETH ANNIVERSARY OF THE ANNOUNCEMENT OF THE THEORY OF NATURAL SELECTION

MODERN biological science may be said to date from the presentation by Charles Darwin and Alfred Russel Wallace to the Linnean Society on July 1, 1858, of the theory of the origin of species by means of natural selection. The title of the joint paper was "On the Tendency of Species to form Varieties and on the Perpetuation of Varieties and Species by Natural Means of Selection." This paper was presented to the society by Joseph D. Hooker and Charles Lyell, and the circumstances of the case are familiar to most readers of this journal.

It will be remembered that Mr. Wallace sent Darwin a paper written at Ternate in the Malay Archipelago in February, 1858, "On the Tendency of Varieties to depart Indefinitely from the Original Type." The argument was strikingly similar to that of a manuscript work on species which Darwin had sketched in 1839 and copied in 1844, when it was read by Hooker and its contents subsequently communicated to Lyell. During all this time Darwin had been accumulating facts and weighing objections to the theory. It was his first intention to allow Wallace's paper to be printed without his own, but he was persuaded by Hooker and Lyell to assent to a joint presentation of his sketch, together with a letter to Asa Gray dated September 5, 1857, and the paper by Wallace before the Linnean Society. With an introduction by Lyell and Hooker, it was read by the secretary to the society in July, 1858, and published that year in its journal. The papers were reprinted in the issue of THE POPULAR SCIENCE MONTHLY for November, 1901.

The fiftieth anniversary of this event has now been adequately celebrated by the Linnean Society. It was of special interest that Dr. Wallace and Sir Joseph Hooker were present and made addresses. With the admirable generosity which has always characterized the relations of the two men, Wallace yielded the superior part to Darwin. He pointed out a certain similarity in their careers—both had been collectors



THE DARWIN-WALLACE MEDAL OF THE LINNEAN SOCIETY.

A sket·h from life by V. Monkhouse published in Knowledge.

DR. FRANCIS DARWIN,
President of the Dublin Meeting of the British Association.

in early life, both had traveled extensively, and both had at the critical moment read Malthus's "Essay on Population." Darwin himself, however, has pointed out that they differed in so far as he was led to his views from a consideration of what artificial selection has done for domestic animals. Sir Joseph Hooker described the events preceding and at the time of the presentation of the paper, from which Darwin was absent through illness. A medal struck by the society—here reproduced by the courtesy of his secretary—was presented in gold to Dr. Wallace and in silver to Sir Joseph Hooker, Professor Ernst Haeckel, Professor Eduard Strasburger, Professor August Weismann, Dr. Francis Galton and Sir E. Ray Lankester. Responses were made by Professor Strasburger, Dr. Galton and Sir E. Ray Lankester, and by delegates from universities and academies, including Dr. Francis Darwin and Lord Avebury.

The hundredth anniversary of the birth of Darwin will occur on February 12 of next year, which is also the hundredth anniversary of the birth of Lincoln. The event will be celebrated by the University of Cambridge, and in this country by Columbia University and the New York Academy of Sciences and doubtless elsewhere. The American Association for the Advancement of Science will, at its Baltimore meeting, give special prominence to exercises in honor of the hundredth anniversary of Darwin's birth and the fiftieth anniversary of the publication of "The Origin of Species."

THE DUBLIN MEETING OF THE BRITISH ASSOCIATION

The recent meeting of the British Association had a program of the usual high standard and an attendance of 2,270 members and associates. The size of the meeting was about the same as the larger convocation-week meetings of the American Association and its affiliated societies, but the number of scientific men and of scientific papers is greater in this country. There were at Dublin 1,374 associates, mainly people living in Dublin and vicinity, who joined the association for the meeting, though not especially interested in science. The American Association has not been able to attract to its meetings people of this class. This is doubtless in part due to better social organization in Great Britain—the sentiment which leads the London *Times* to devote pages to reports of the meeting and every country house to take in *Nature*—but it is also in part due to the fact that the meetings are made more attractive to those not professionally engaged in scientific research. It seems that our association should aim to do more for this class, for from it science needs sympathy, support and recruits.

Mr. Francis Darwin, the president of the meeting, who, like his brother, Sir George Darwin, the president of the South African meeting three years ago, bears worthily his great name now being celebrated on the occasion of the fiftieth anniversary of the publication of the "Origin of Species," chose as the subject of his inaugural address the reactions of plants. His own experimental work has been largely in this field, and the address was made interesting to a large audience by a discussion of consciousness in plants and the hereditary transmission of acquired characters. Public lectures were given by Professor H. H. Turner, of Oxford, on "Halley's Comet" and by Professor W. M. Davis, of Harvard University, on "The Lessons of the Colorado Cañon." The annual lecture to the working classes was by Dr. A. E. Tutton, on "The Crystallization of Water."

The entertainments and excursions were as usual very elaborate. The reception given by the Royal Dublin Society was attended by 4,000 guests, and there were numerous luncheons

Dr. J. J. Thomson,
Cavendish Professor of Experimental Physics at Cambridge University,
President of the Winnipeg Meeting of the British Association.

and garden parties. Special services were held in the Episcopalian, Presbyterian and Roman Catholic churches, and the University of Dublin conferred honorary degrees on a number of the distinguished visitors.

The large annual membership of the association and the comparatively large fee enable it to make liberal grants for scientific research, amounting this year to about $7,000. Among the grants of $250 or more were the following: Professor H. H. Turner, for seismological observations; Sir David Gill, towards building a solar observatory in Australia; Sir W. H. Preece, for the study of gaseous explosions; Professor J. Joly, for geological investigations at Briske, and Mr. D. G. Hogarth, for archeological explorations in Crete.

Dr. J. J. Thomson, Cavendish professor of experimental physics at Cambridge and eminent for his research work concerned with the X-rays, radium and the breaking up of the atom, was elected president for the meeting to be held next year at Winnipeg, beginning on August 25. Members of the American Association are invited to attend this meeting, and those who are able to be present are certain to enjoy unusual pleasure and profit.

THE PRESENT PANDEMIC OF PLAGUE

The bulletin with this title prepared by Assistant Surgeon General, J. M. Eager, and issued by the Public Health and Marine Hospital Service, exhibits in a bald way the relentless forward march of the bubonic plague, a circumstance more terrible and dramatic perhaps than anything else in contemporary history. Emerging from the obscure endemic focus in the province of Yunnan, China, in the year 1894, the plague appeared in Canton, and there were a hundred thousand deaths between March and August. The disease spread to Hong Kong and in 1896 to Bombay, there being some two thousand deaths in the presidency. In 1897 there were over 55,000 deaths in India, including nearly 10,000 in the city of Bombay, with sporadic cases in Japan and Turkey. In 1898 there were 117,000 deaths in India, and extending far from its endemic home, there were cases in Madagascar and Mauritius. In 1899 there were 135,000 deaths in India and serious epidemics in China. Cases occurred in Egypt and the Hawaiian Islands, and South America was invaded. There were local epidemics in Portugal and Russia. In 1900 there was a diminution in India, the deaths falling to 92,000, but the disease invaded San Francisco and was present, and remains present, in every quarter of the world, Europe, Asia, Africa, Oceanica, North and South America. In 1901 the hope of relief in India was disappointed, the deaths rising to 278,000, and in 1902 to 575,000. They increased further to 835,000 in 1903, and to the neighborhood of one million in 1904 and 1905, falling in 1906 to 332,000, but rising again last year to the appalling record of 1,400,000 cases and 1,200,000 deaths. The plague was present in all quarters of the world, there being 156 cases and 76 deaths in San Francisco, and cases in the suburbs and in Seattle.

If it were not for the great advance of modern medicine western civilization would be threatened with a disaster unparalleled since the middle ages. But the means by which the plague is transmitted have been discovered—we can exterminate fleas and rats if necessary—and, thanks to the labors of scientific and medical men, not a few of whom have sacrificed their lives, we are comparatively secure. But protective measures and more knowledge are needed here and in many directions, and the governments of the world should spend not less care and money on them than on their armaments.

SCIENTIFIC ITEMS

We record with regret the deaths of Dr. Charles Harrington, professor of hygiene in the Harvard Medical School and chairman of the Massachusetts State Board of Health; of the Earl of Rosse, F.R.S., who, like his father, made valuable contributions to astronomy; of M. E. Mascart, since 1871 director of the French Meteorological Office, and of General J. F. Nery Delgado, for many years director of the Geological Survey of Portugal.

The Academy of Sciences at Turin has awarded its Riberi prize of the value of $4,000 to Professor Bosio, of Turin, for his discoveries in relation to the biological reactions to arsenic, tellurium and selenium.—The British Ornithologists' Union will celebrate its fiftieth anniversary in December next, when gold medals will be presented to the four surviving original members: Dr. F. Du Cane Godman, F.R.S., Mr. P. S. Godman, Mr. W. H. Hudleston, F.R.S., and Dr. P. L. Sclater, F.R.S.

Professor L. H. Bailey has been given leave of absence from the directorship of the College of Agriculture of Cornell University to devote his time to the chairmanship of the commission appointed by President Roosevelt to investigate the conditions of rural life. The other members of the commission are: Henry Wallace, of *Wallace's Farmer*, Des Moines, Ia.; President Kenyon L. Butterfield, of the Massachusetts Agricultural College; Gifford Pinchot, chief of the Forest Service, and Walter H. Page, editor of the *World's Work*.—Dr. Charles H. Judd, professor of psychology at Yale University, has been elected dean of the school of education and head professor of the department of education at the University of Chicago, the appointment to take effect at the close of the present academic year.

The Berlin Academy of Sciences has received a legacy of $7,500,000 from Herr Samson, a banker of that city. —M. Henri Becquerel has bequeathed $20,000 to the Paris Academy of Sciences in memory of his grandfather and his father, who were members of the academy.

THE POPULAR SCIENCE MONTHLY.

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THE CAUSE OF PULSATION

BY ALFRED GOLDSBOROUGH MAYER

DIRECTOR OF THE DEPARTMENT OF MARINE BIOLOGY OF THE CARNEGIE INSTITUTION OF WASHINGTON

THE following is an account of a research which was pursued at the Marine Laboratory of the Carnegie Institution at Tortugas, Florida.

An interesting jellyfish, *Cassiopea xamachana*, lives upon the muddy bottoms of the lagoons of coral islands in the Florida and West Indian regions. Here the stilted roots of dense green mangroves fringe many a lagoon whose half stagnant waters have never felt the surge of ocean waves. Looking down through the clear depths one sees the bottom almost carpeted with the *Cassiopea* medusæ. Over wide areas they lie with their disks nearly touching and their bell-rims languidly pulsating. At a glance one might mistake them for sea-weeds, deceived as one would be by their delicate blue-green and gray-blue color, and by the tree-like shape of the branching appendages which bear the mouths of the medusa, and which project upward and outward hiding the pulsating disk below them.

At regular intervals around the rim of the jellyfish we find about sixteen minute club-shaped organs, each set within a deep niche. The microscope serves to show us that each of these little clubs contains at its outer end a mass of crystals, and upon one side a simple cup-like eye. Even in medusæ six inches in diameter these sense-clubs are smaller than the heads of the smallest pins; mere specks barely discernible to the eye, yet if they be cut off we find that the medusa ceases to pulsate, while the cut-off portion of the rim still contracts rhythmically. It is thus evident that the stimulus which produces each and every pulsation arises in the sense-clubs.

The question is, why is it that the central disk of the medusa does not pulsate in sea-water when its sense-clubs are removed? Curiously enough, if we stimulate the disk in any manner, such as by a mechanical or electrical shock, or by touching it with a crystal of common salt, it gives a few vigorous pulsations and then lapses into quiescence.

But if we cut out the center of the medusa and also remove the rim, thus forming a ring tissue without sense-organs (Fig. 2), this

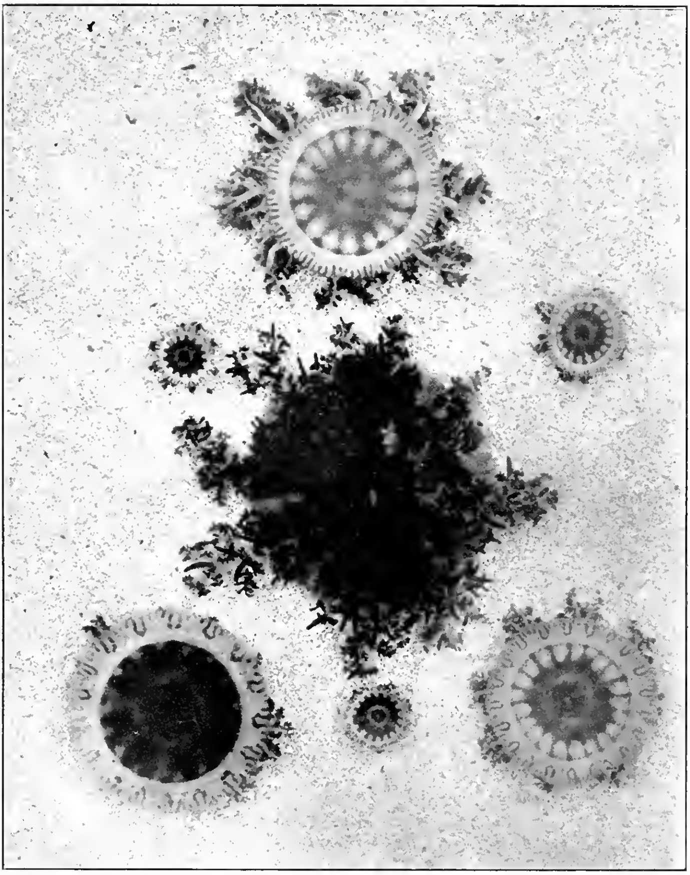

FIG. 1. LIVING MEDUSÆ OF *Cassiopea xamachana* ON A SANDY BOTTOM. The large medusa in the middle is in the natural attitude with its mouth-arms uppermost. The smaller medusæ have been turned over in order to show their pulsating disks.

ring remains quiescent in sea-water unless we stimulate it at any point such as at *S* with a single momentary touch of a crystal of potassium, or in some other manner, when a contraction-wave starts out from the point touched. In a narrow ring, however, the waves can go only in opposite directions from the stimulated point. Now one of these waves is apt to be strong and the other weak; for the nervous network which

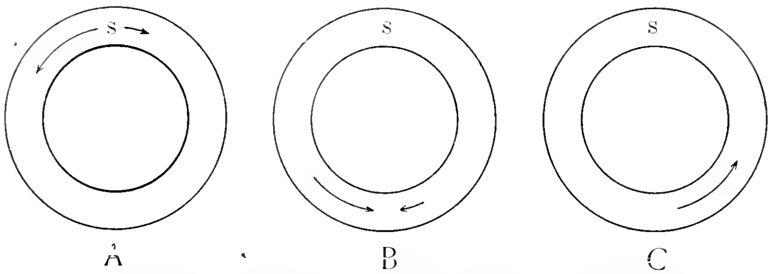

FIG. 2. SHOWING HOW A PULSATION-WAVE MAY BE "ENTRAPPED" IN A CIRCUIT OF TISSUE.

transmits them is almost certain to be more complete on one side than on the other of any stimulated point. Of course the waves meet as in Fig. 2, *B*, and then the strong wave destroys the weak one and continues around the ring. There is then only one wave left in the circuit and this travels constantly around (Fig. 2, *C*) for hours or days until something stops it, such as the cutting of the circuit or a fresh stimulus which produces a wave that meets and destroys it.

The weak wave was destroyed by the strong one in the above experiment because a weak stimulus can not set tissue into pulsation, which has been caused to pulsate through a strong stimulus, until after an appreciable interval of rest. Thus a weak stimulus following *immediately* after a strong one will produce no contraction, whereas a strong stimulus may cause tissue to pulsate even immediately after it has responded to a weak one.

It is now evident that the disk without its sense-organs *can* pulsate in sea-water if only a wave be once started in it, but that under normal conditions there is nothing to *start* a wave, and thus the disk remains quiescent. In other words, the sea-water is indifferent, and neither stimulates nor inhibits pulsation.

It is now time for us to determine why it is that the sea-water does not stimulate the disk when its sense-organs are removed. In the first place we must know the composition of sea-water, and chemical analysis shows that it consists of a mixture of sodium chloride (common salt), magnesium chloride and sulphate, potassium chloride, and calcium chloride and sulphate.

Numerous experiments show us that the common salt is a strong stimulant to both nerves and muscles. On the other hand, magnesium, calcium and potassium, all inhibit and do not stimulate the disk. Indeed, the stimulating effect of the common salt in the sea-water is exactly offset by the subduing tendency of the magnesium, calcium and potassium; and thus it is that the sea-water as a whole neither stimulates nor inhibits the pulsation of the jellyfish. The sea-water maintains the medusa in a delicately balanced fluid for it contains poisons and antidotes as does our blood, which exactly counteract one the other. For example, the jellyfish dies in less than two hours if placed in a solution having the amounts and proportions of the common salt and the potassium of the sea-water, but if we simply add the calcium it pulsates very rapidly for more than twenty-four hours. Finally, however, the calcium produces so strong a muscular tetanus that the pulsating tissue is torn literally to shreds; but all of these injurious effects disappear when we add the magnesium, which causes the pulsation to become much slower and more regular, and wholly prevents the calcium from producting tetanus. Another curious fact is that were it not for the presence of the calcium the magnesium would so stupefy the nervous and muscular tissue that no pulsation could arise. This is the more remarkable because magnesium and calcium are both inhibitors of pulsation, yet when both are present they tend in a measure to offset each other, magnesium mainly inhibits the muscles, while calcium stupefies the nerves.

But to return to our subject, let us carry out some experiments to discover the nature of the stimulus which produces each pulsation of the jellyfish. If we cut a ring from the medusa's disk such as is shown in Fig. 3 and leaves a long narrow strip *AB* attached to it, and then start a contraction-wave traveling around the ring; every time the wave passes the point *A* a side-tracked portion of the wave will pass along the strip from *A* to *B*. When each side-tracked wave comes to the end *B* it dies out, for it can not return over the recently stimulated tissue along which it has just passed. Thus we see that the index strip *AB* simply serves to catch a portion of each wave which passes its base.

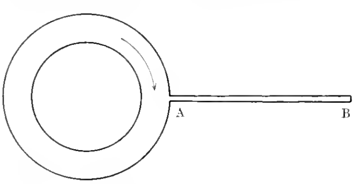

FIG. 3. A PULSATING RING WITH AN "INDEX-STRIP."

Now suppose we place the ring in a pure solution of magnesium chloride, and allow the index strip *AB* to remain in natural sea-water. Then the contraction-wave gradually dies out in the pulsating ring, for the magnesium paralyzes the muscles; and at the end of about a quarter of an hour all movement will have ceased in the ring, but long after this we find that the strip *AB* still continues to transmit contractions at regular intervals of time. We see then that whenever the something which produced the contraction in the ring comes around to the point *A* it is still capable of setting up a contraction in the strip *AB*, although it can not now cause the muscles of the ring itself to pulsate.

The explanation is that the stimulus which produces pulsation is nervous in nature, and travels through the nervous tissue quite independent of the presence or absence of the muscles. When therefore the magnesium paralyzes the muscles the nervous stimulus still travels around the ring even though the muscles can not now respond to it by contraction.

We now are in a position to state that each pulsation is due to a nervous stimulus which originates somehow in the sense-organs. The question is, how does it originate?

In all of the large jellyfishes called Scyphomedusæ, the marginal sense-organs are little clubs, the axial cores of which *always* contain a terminal mass of crystals. These crystals consist of calcium oxalate with a slight addition of uric acid and urea. The uric elements are relatively inert and need not be further considered. The presence of calcium oxalate, however, acquires some meaning when we find that the sense-organs can not continue to give rise to pulsations unless they be constantly supplied with soluble calcium, and all movement ceases in a few moments if the jellyfish be placed in sea-water deprived of calcium. We see at once that there must be some oxalate which is constantly forming in the sense-organs, and which is precipitating the soluble calcium chloride and sulphate of the sea-water to form the insoluble calcic oxalate crystals of the sense-club.

The question before us is, what oxalate is being formed in the sense-organs? We know that in certain tissues in the bodies of animals oxalic acid, and other oxalates, are formed apparently through the incomplete oxidation of carbohydrates. Now we find that even so small a quantity as one part by weight of oxalic acid in one thousand parts of sea-water paralyzes the sense-organs and permanently *prevents* their giving rise to pulsation, although so weak a solution is not sensibly poisonous to the general tissues of the medusa. Also the oxalates of potassium and magnesium finally inhibit pulsation, and it can not be that any of these is the cause of pulsation in the sense-organs.

The key to the mystery seems to be found, however, when we immerse the sense-organs in a solution of from 1 to 5 parts of *sodium oxalate* in 1,000 parts of sea-water; for this immediately stimulates them into great activity, whereas it has no effect if applied to any part of the medusa other than the sense-organs.

Now *sodium oxalate* precipitates the calcium which enters the sense-organ from the sea-water to form calcium oxalate, and sets free common salt and sodium sulphate; both of which are powerful nervous and muscular stimulants. The chemical formula for this reaction is as follows:

$$Na_2C_2O_4 + CaCl_2 = 2NaCl + CaC_2O_4.$$
$$Na_2C_2O_4 + CaSO_4 = Na_2SO_4 + CaC_2O_4.$$

Fig. 4. Where *Cassiopea* lives. Lagoon of Bahia Honda Cay, Florida Coral Reef.

Thus the sodium oxalate which forms in the sense-organs is simply changed into ordinary table salt, which acts as a stimulus to produce pulsation.

We can prove experimentally that this suffices to explain the phenomenon of pulsation, for if we simply add from 1 to 5 parts of common salt to 1,000 parts of sea-water, we find that this slight excess of salt acts as a powerful stimulant to the sense-organs, but produces no pulsation if placed upon other parts of the jellyfish.

It thus appears that each sense-organ normally maintains a certain excess of common salt which acts as a stimulus, and which is prevented from becoming too concentrated by the fact that being soluble it is constantly dissolving out into the surrounding sea-water.

It may trouble us for a moment to see why a recurrent pulsation should arise from a constantly present stimulus, but long ago Romanes discovered that a weak constantly present stimulus, such as a faradaic current of electricity, will cause rhythmical pulsation, the jellyfish responding to it periodically and regularly.

We see then that the natural stimulant which produces the pulsation of the jellyfish is only that most familiar substance common salt!

The hearts of higher animals behave in a manner so similar to that of the pulsating jellyfish that we need not be surprised if it be demonstrated that here also a slight excess of *sodium chloride* gives rise to each and every pulsation.

A BIOGRAPHICAL HISTORY OF BOTANY AT ST. LOUIS, MISSOURI[1]

By Dr. PERLEY SPAULDING

LABORATORY OF FOREST PATHOLOGY, BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE

THE history of botany in St. Louis extends back nearly to the beginning of her political history. The city was founded in 1764, and while it is not as old as most of the other large cities of this country it seems to have been one of the earliest settlements made in the great northwestern region, comprising what was once known as Upper Louisiana. Boston, New York and Philadelphia were already large cities for that time and were centers of botanical activity. In 1795 when Michaux visited the Illinois Territory, Cahokia, Kaskaskia and St. Louis were the principal places west of Vincennes and as late as 1800 St. Louis had a population of less than 1,000. At about this time the fur traders changed their headquarters from Cahokia and Kaskaskia to St. Louis, causing a corresponding increase in population and commercial influence of the latter town.

The Jesuit missionaries were the first white persons to visit the Mississippi Valley and the adjoining country; they undoubtedly explored the Missouri Territory, but probably not so extensively as they did the Illinois Territory. They were versed to some extent in the art of medicine and knew the plants which were generally used for medicinal purposes. They learned the uses of plants new to themselves from their Indian wards, and in this way they must have obtained a considerable knowledge of the plants of the Missouri country. How much farther they may have carried their botanical studies is unknown to the writer. During the period between the founding of St. Louis and the first visit of Michaux to Cahokia there were undoubtedly persons who studied the botany of the St. Louis district. Whether they formed any collections of the plants is not now known and there seems to be no records of any such study.

For all practical purposes André Michaux may be said to have been the first botanist to work in the vicinity of St. Louis.

Botany has passed through a number of distinct periods at St. Louis, as in other places; it can not be said to have had a "pharmaceutical" period, as that stage was nearly past in the general history of the science when the city was founded. The medical properties of

[1] Published by permission of the Secretary of Agriculture.

the plants of the eastern states and of Europe were already well known at the close of the eighteenth century. Of course many new western plants were discovered, the medical properties of which had to be determined; but this was not the main object in making a study of them. We find three distinct periods of botanical work which include the one hundred and thirteen years that have elapsed since Michaux's visit. These may be designated as follows: First, exploration by botanists on transient visits of a few days' to a few months' time; second, collecting by persons who lived in or near St. Louis for a number of years; third, modern botany as contrasted with the purely systematic work of early days. These three periods overlap one another, but can still be distinguished without difficulty. The first includes most of the work done previously to 1850; the second began with the work of Engelmann and his numerous contemporary collector friends, who relied upon him for assistance in naming their collections; it may even be said to extend until the present time, as considerable work is still being done upon the local flora of the district; the third period may be said to date from the founding of the Shaw School of Botany, and the assumption of control of the Missouri Botanical Garden by the board of trustees.

André Michaux, the great French botanist, who explored so extensively the territory of the thirteen original colonies as far west as the Mississippi River, is the first botanical worker concerning whom published records have yet been found as having worked in the vicinity of St. Louis. He is known to have visited Kaskaskia and Cahokia, and the evidence seems to indicate that he must have visited the west shore of the Mississippi, since a few species are listed in his "Flora" as coming from the Missouri River.

André Michaux[2] was born at Satory, near Versailles, France, in 1746. He was destined by his father for the superintendence of a farm of the royal estate, and early became interested in agriculture. Upon the death of his young wife, at the birth of their son, François André, he devoted himself to scientific studies, especially botany. He studied botany under Bernard de Jussieu, and sought in foreign lands for strange plants. In 1779–81 he traveled in England, the Auvergne, the Pyrenees and Spain. In 1782–5 he was in Persia in a political capacity, but really to explore a country at that time almost unknown to scientific men; he intended to return to Persia, but was requested in 1785, by the French government, to introduce into France such North

[2] Hooker, W. J., *Amer. Jour. Sci. and Arts*, 1st series, 9: 266–269, 1825.
Gray, Asa, Ditto, 1 ser., 42: 2–9, 1842.
Coulter, J. L., *Bot. Gaz.*, 8: 181–183, 1883.
Rusby, H. H., *Bull. Torrey Bot. Club*, 11: 88–90, 1884.
Sargent, C. S., "Scientific Papers of Asa Gray," 2: 23–31, 1889.
Thwaites, R. G., "Early Western Travels," 3: 11–19, 27–104, 1904.

American trees as might be of economic importance. In the autumn of 1785 he embarked for New York, accompanied by his young son; here he spent a year and a half collecting plants and starting a botanical garden in Bergen County, New Jersey; he found, however, that the southern climate was more suitable for many of his plants, and he accordingly removed to Charleston, South Carolina, in 1787, where he established another garden, about ten miles from the city. During this year he explored the mountains of the Carolinas; the next he journeyed through the swamps of Florida, and the next he visited the Bahamas, and again searched the mountains for plants of economic importance—especially ginseng. In 1792 he collected around New York and in New Jersey; thence he went up the Hudson to Albany and along Lake Champlain, reaching Montreal June 30, 1792. From Montreal he went to Quebec, and thence by way of the Saguenay to Hudson's Bay. He then returned to Philadelphia, where he proposed to the American Philosophical Society an exploration of the great western territory, by way of the Missouri River. A subscription was begun for the purpose, and Thomas Jefferson drafted detailed instructions for the journey. Michaux, indeed, is stated to have started west and to have proceeded as far as Kentucky when he was overtaken by an order from the French government to relinquish the journey for a political mission. This mission seems to have had for its object the control of Louisiana by the French, through the aid of the trans-Allegheny Americans. In carrying out this plan Michaux made a journey in 1793 to Kentucky by way of the Ohio River, and returned over the "Wilderness" road, and through the valley of Virginia. Early in 1794 he made another extensive tour in the southern states and the North Carolina mountains. In 1795–6 he made a much longer journey, going from Charleston to Tennessee, thence through Kentucky to Vincennes, Indiana, where he stayed from August 13 to 23. From here he went to Kaskaskia, and from there he visited Cahokia and the vicinity. Upon looking over his "Flora Boreali Americana" we find several species of plants mentioned therein as coming from the Missouri River. It seems quite probable then that he must have visited some locality near this river during this trip, as this is the only visit to this section of which we find any mention in his journal. He mentions St. Louis as being in a prosperous condition, but makes no further allusion to it. Except for the evidence of these few species as given in his "Flora," we should not know that he had gone west of the Mississippi River, and this, of course, is somewhat uncertain, as it is very possible that some person at Cahokia, who may have been on the Missouri River, had out of curiosity picked up some strange plants and happened to bring them to Cahokia at the time Michaux was there. He made a short visit here and then went to Fort Massac, near the mouth of the Tennessee River, and from there proceeded up the Cumberland River by boat, as far as Clarksville; he then visited Nashville, Knoxville, Louisville, and Morganton, finally arriving at Charleston again in April, 1796. During all of this time he collected eagerly, and more or less extensively. His journals, however, give no indications of the species or the number of them found at Cahokia. He seems to have found a considerable number at Kaskaskia, at which place he spent most of his time while in Illinois. In his "Flora" we find mentioned about 100 species as occurring in the Illinois territory; this, however, at that time included all of the territory north of the Ohio which was visited by Michaux. This seems to have been his last extensive trip in America; and in August, 1796, he embarked for Amsterdam and was shipwrecked on the coast of Holland. He is said to have been nearly drowned himself, and a large part of his collections were lost. He remained in France for several years, studying his collections and preparing the manuscript for his "Flora." In 1800 he joined an expedition to Australia, but, becoming disgusted with the management, he landed on the Island of Mauritius, but from there he soon went to Madagascar; here he established a botanical garden and began collecting extensively; but he soon fell victim to the unhealthy climate, and died on November 13, 1802.

Michaux probably traveled more extensively in North America than any other early botanist. He was the author of numberless new species and many new genera of American plants. Unfortunately, the genus, *Michauxia*, which commemorates his name, is one discovered by himself in Persia; so that his name is not thus associated with North American botany, which was so greatly advanced by his studies and explorations.

Immediately following the exposition held at St. Louis in commemoration of the purchase of Louisiana from France, there was held another exposition upon the Pacific coast to celebrate the centennial of the arrival of the Lewis and Clark expedition at the mouth of the Columbia River. This expedition was the first to penetrate overland to the Pacific coast and the results of its successful termination were of immense importance to the entire northwestern country. The journals of the expedition contain many references to plants seen, and especially to those which were peculiar or interesting, or which were used by the Indians.

In the previously mentioned attempt at the exploration of the northwest country, Michaux was to accompany the party. In the expedition which finally did make the journey there was no person who could be called a botanist. Although Captain Lewis was a very keen and observant man, he could not overcome his lack of botanical training, and the results in this regard were hardly what they would have been had Michaux been with the expedition. The journey up the Missouri River was made in boats manned with oars and, owing to the rapid current of the river, progress was slow, thus affording opportunity for a considerable amount of collecting to be done. During the ascent of the river quite an extensive collection of plants was made, but this had to be left behind when the Rocky Mountains were crossed, and was consequently lost. During the much more hurried return of the expedition another collection was made, but it was much smaller than the first, and comparatively few species seem to have been collected about St. Louis. While this expedition did but little for St. Louis botany directly, it turned the public attention to this section, and finally led to careful botanical exploration by a number of capable botanists a few years later.

Captain Meriwether Lewis[3] was born near the town of Charlottesville, Virginia, on August 18, 1774. His family was one of the most

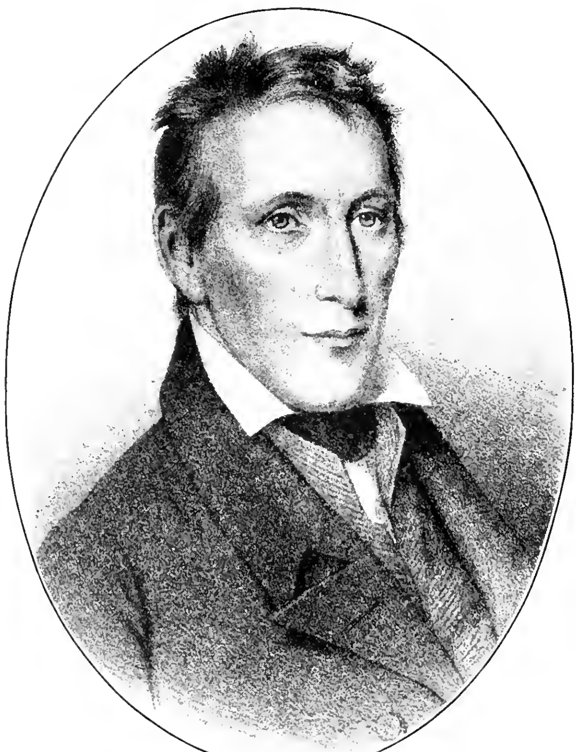

FIG. 1. CAPTAIN MERIWETHER LEWIS; from *Analectic Magazine and Naval Chronicle*, Vol. 7, 1816.

distinguished of that state. Several of his uncles were very prominent in their time, one of them having married a sister of George Washing-

[3] Jefferson, Thomas, "Biography of Capt. Lewis in Analectic Magazine and Naval Chronicle," 7: 329 333, 1816.

Allen, Paul, "History of the Expedition under the Command of Captains Lewis and Clark," etc., 1814, reprint by New Amsterdam Book Company.

ton. Meriwether lost his father early in life, and one of his uncles acted as his guardian. At the age of thirteen he was sent to the Latin school, where he remained until he was eighteen, when he returned home to help run the farm. At the age of twenty he entered as a volunteer a body of militia which was called out by General Washington to quell troubles in the western states, and from the militia he entered the regular service as a lieutenant. When twenty-three years old he was promoted to a captaincy and made paymaster of his regiment. He was personally well known to Thomas Jefferson, and when the latter proposed that two persons should be sent up the Missouri River, across the Rockies and down the Columbia to the Pacific Ocean, he eagerly offered to go. A few years later Jefferson, remembering the eagerness of Captain Lewis to make the trip, made him leader of the expedition, which successfully carried out the plans, and is now known as the Lewis and Clark Expedition. Captain Clark was made the leader in the absence of Lewis. The expedition started in 1803 and returned in 1806. Congress gave both leaders grants of land, and Lewis was made governor of the territory of Louisiana, while Clark was made a general of militia and agent for Indian affairs. Upon assuming his duties as governor, Lewis found many factions and parties, but his even-handed justice to all soon established respect for himself, and eventually removed animosities. While on a trip to Washington he suffered a temporary attack of insanity, and committed suicide on October 11, 1809.

Pursh has named a genus of the Portulacaceæ, *Lewisia*, in his honor.

During the early part of the nineteenth century it was much the fashion for botanists to collect living plants and cultivate them in gardens, these gardens sometimes being quite extensive. Sometimes they were but temporary resting places for the plants until they could be sent to European countries as novelties to be introduced there because of some desirable quality. André Michaux had such gardens into which he gathered his plants, and when opportunity offered sent them to France. Many of our early botanists had their own gardens in which they cultivated all of the different plants they could find, and thus became acquainted with every detail concerning them. The Bartram and Marshall gardens near Philadelphia were good examples of these early collections of living plants.

Among many persons sent from Europe to this country for the purpose of collecting new and rare plants was one John Bradbury,[4] who was commissioned to act as the agent of the Liverpool Botanical So-

[4] Bradbury, John, "Travels in the Interior of America in the Years 1809, 1810 and 1811," 1–346, 1819, 2d edition.

Short, C. W., *Transylvania Jour. of Med.*, etc., 34: 12–13, 1836.

Britten, Jas., and Boulger, G. S., "Biographical Index of British and Irish Botanists," 21, 1893.

ciety. Comparatively little seems to be known about Bradbury. He was a Scotchman who had lived for a long time in England, when he received his commission from the Liverpool Botanical Society in 1809. Upon arriving in this country, Bradbury spent several days at the house of Thomas Jefferson, so that the latter became acquainted with him and his abilities. Jefferson spoke highly of him as a naturalist, and Short, a later writer, mentions him as "an English gentleman of very respectable attainments as a naturalist." In the light of our present knowledge he seems to have fully deserved such an estimation, as he discovered a considerable number of new species as well as a new genus of plants during his travels in the Missouri country. Indeed, several of our more characteristic species bear his name, and in later years he was honored by Torrey and Gray, who named a new genus *Bradburia,* in commemoration of his services in exploring our western flora.

Mr. Bradbury at first intended to make New Orleans his center of operations, but following the advice of Jefferson he changed that intention and came to St. Louis instead. He descended the Ohio River by boat, making such observations and collections as he could at the various stopping places, arriving at St. Louis on the last day of the year 1809. The entire season of 1810 was spent about St. Louis, making short excursions of not more than eighty or one hundred miles distance in all directions, and he accumulated a considerable collection of plants which were sent to Liverpool the succeeding autumn. No definite data can now be obtained as to the number of species contained in these collections, as Bradbury never published a complete list of them, although he did give a list of the rare and more interesting plants in his journal, which was published after his return to England.

Early in the spring of 1811 Bradbury, accompanied by a young and zealous botanist named Thomas Nuttall, joined a fur-trading expedition, and with them ascended the Missouri River as far as the Mandan villages, not far from the site of the present town of Bismarck, North Dakota. Upon reaching this point the expedition divided and part of it, including Bradbury, returned to St. Louis. The others went on still farther, and Nuttall remained with them until their return to St. Louis some months later. This voyage was made in a steamer, and progress was necessarily slow while going up the river, so that our naturalists had ample time and opportunity for collecting. A collection even larger than that which had been made around St. Louis is said to have been accumulated.

Before Bradbury had finished his preparations for departure to England, the war of 1812 broke out, and he remained for several years in this country until the close of hostilities. He finally reached Liverpool in 1815, and found that during his long absence his plants had been inspected by Pursh, who was at that time in England preparing the manuscript for his "Flora Americanæ Septentrionalis." Pursh published the most interesting of these plants in an appendix to his work, and this seems to have discouraged Bradbury from publishing as extensively upon them as he probably would have otherwise done. In 1817 Bradbury published his journal of travels on the Missouri in the years 1809–10–11, and in an appendix to this gave a list of the rare and most interesting plants of his collections. He did not, however, issue a complete list, and so far as now known no such list has ever been published. The second edition of his travels was issued in 1819, and in the editor's preface it is stated that Mr. Bradbury had already returned to St. Louis and taken up his residence there. Baldwin, who passed through St. Louis in 1819 with the Long expedition, mentions meeting Mr. Bradbury there at that time. His name is given in the St. Louis city directory for 1821,[5] but no definite information regarding him after this date has yet been found.

During the early part of the nineteenth century it was the policy of the national government to send expeditions of a military character to explore the unknown sections of the western country. Shortly after Bradbury made his tour of the Missouri, an expedition was fitted out and placed under the command of Major S. H. Long. This was intended to make more complete and detailed exploration of the Missouri and its main tributaries, and to make more accurate scientific observations of the country passed through. The necessity of having competent scientific men accompany the expedition was recognized, and several such men were appointed for the purpose.

The botanist of the expedition was Dr. William Baldwin.[6] He was a son of a minister of the Friends in Pennsylvania, being born in Newlin, Chester County, in 1779. He studied medicine at the University of Pennsylvania and took his degree in 1807. Meanwhile he had become interested in the study of botany, and upon settling in Wilmington, Delaware, to commerce practising his profession, he collected extensively in the vicinity. Pulmonary weakness forçed him to remove to Georgia in 1811, where he served as surgeon to a gunboat flotilla during the war of 1812. He kept up his collecting and study of the plants of this new region, and because of his ability as a botanist he received an appointment as surgeon to the U. S. frigate *Congress,* during a cruise to various South American ports. Baldwin made extensive collections and notes wherever opportunity offered, and he returned with a

[5] Learned by the aid of the St. Louis Historical Society.

[6] Thwaites, R. G., "Early Western Travels," Vol. 14.
Darlington, William, "Reliquiæ Baldwinianæ," 1–346, 1843.
Redfield, John, *Bot. Gaz.*, 8: 233–237, 1883.
Harshberger, J. W., "Botanists of Philadelphia," 119–125, 1899.

very considerable amount of valuable material. About this time the Long expedition was being organized, and Baldwin was recommended to act as botanist for the party. His health was delicate and the appointment was accepted in the hopes that it would be improved by the journey.

Baldwin joined the other members of the scientific staff at Pittsburg and embarked upon the steamer which was to take the expedition to Council Bluffs. This being the early days of steamboating, the one used by the expedition gave more than ordinary trouble and caused

Fig. 2. Dr. William Baldwin; from Darlington's "Reliquiæ Baldwinianæ."

vexatious delays. According to the letters of Baldwin it also leaked continually, and this made the interior damp and totally unsuited for such a prolonged voyage. Baldwin's health constantly grew worse, and even while descending the Ohio River the party halted to allow him to recover from an attack of illness, and he was forced to depend upon the others to bring specimens to him on the boat, as he had not sufficient strength to walk any considerable distance. St. Louis was finally reached on June 9 and a stop of several days was made. The voyage was resumed on the twenty-first, and on July 13 they reached Franklin, then the uppermost town of any importance on the Missouri. Here Baldwin was left behind at the house of Dr. Lowry, where he remained until his death on August 31. During his stay in Franklin Baldwin botanized as much as his limited strength would permit, and entries were made in his diary as late as August 8, the date of the last entry. A list of plants found around Franklin by him during this time attests the earnestness with which he pursued his beloved science. The journals of the expedition show that he collected about one hundred species in the vicinity of St. Louis and on the Missouri to Franklin.

His companions all unite in praise of his devotion to science and his persistence under such extremely trying circumstances. Notwithstanding his extensive travels and his earnest study of the botany of several different sections of this country and of South America, he published but little. Two short articles, presented for publication just before starting with the expedition, are all that are known to have been published by him. He left numerous manuscripts and notes which have aided Torrey and Gray in their work on the flora of America. His herbarium was extensive and very valuable, and has contributed much to the works of Pursh and Nuttall. Baldwin also contributed to Muhlenberg's catalogue, and he maintained an active correspondence with many of the foremost botanists of his day. Nuttall has honored him by naming a genus of the Compositæ *Baldwiniana,* and has thus connected him in a most permanent manner with that science to which he so earnestly devoted himself.

The Long expedition proceeded and on September 17 went into winter quarters near Council Bluffs. Major Long meanwhile went east, and on his return brought with him Dr. Edwin James, who had been appointed to take the place of Dr. Baldwin.

Edwin James[7] was born in Weybridge, Vermont, on August 27, 1797. Edwin was the youngest son of Deacon Daniel James, who was a native of Rhode Island, and had moved to Vermont at the beginning of the Revolution. In youth he was very industrious and applied himself to his studies with perseverance. His education was obtained at the district school, and later he attended Middlebury College, where he graduated in 1816. Subsequently he studied medicine with his elder brother in Albany, New York, for three years. During this time he became interested in botany and the natural sciences, which were then being taught by Professor Amos Eaton. Upon the recommendations of Captain Lewis Le Conte and Dr. John Torrey he was appointed to the place left vacant by the death of Dr. Baldwin. The trip with Major

[7] Thwaites, R. G., "Early Western Travels," Vol. 15.
Parry, C. C., *Amer. Jour. Sci. and Arts,* 2d series, 33: 428–430, 1862.
Sargent, C. S., "Silva of North America," 2: 96, 1891.

Long was a hurried one, although it was made overland from St. Louis to Council Bluffs and but few plants were collected near St. Louis. James remained with the expedition until its close. His efficient labors are proved by the subsequent publications founded upon his observations and collections. The present Pikes Peak was first named James's Peak, by Major Long, but for some unexplained reason the earlier name has not remained in use.

The next two years after the return of the expedition were spent in compiling his results, which were published in 1825, and were of much historical and scientific value. During the next six or seven years he served as a surgeon in the regular army at extreme frontier posts, and here he studied the Indian languages and translated the New Testament into the Ojibwe tongue. He also published a biography of John Tanner, a man who was captured by the Indians while a child, and was brought up by them. When the medical department of the army was reorganized he resigned and returned to Albany, where he was associate editor of a temperance periodical. Upon leaving this he went west and settled near Burlington, Iowa, where he spent the last days of his life in agricultural pursuits. On October 25, 1861, he was run over by a wagon and injured so seriously that he died three days later.

The genus *Jamesia,* of the Saxifrage family, was named in his honor by Torrey and Gray.

The results of the exploring expeditions seem to have directed attention to the Missouri country, so that a number of men of ability came to that section and made botanical explorations of greater or less extent. Before the Long expedition had finished its work an amateur botanist, Dr. Lewis C. Beck, was collecting about St. Louis.

Dr. Lewis Caleb Beck[8] was born in Schenectady, New York, on October 4, 1798. In 1817 he graduated at Union College; he then studied medicine and began to practise at Schenectady in 1818. He moved to St. Louis in 1820 and lived here until 1822. During this time he collected quite extensively and later published a list of his collections. His introductory note is self-explanatory and is as follows:

> During my residence in Missouri, in the years 1820, 1821 and 1822, a portion of my time was occupied in the investigation of the vegetable productions of that and the adjoining state. Upon my return I was so fortunate as to receive, uninjured, the collections which I had made.
>
> Until the present season (1826), however, I have not had leisure to examine them with the necessary attention, and to revise my notes upon the recent plants. This work I have now commenced, and submit to you the first part,

[8] Appleton's "Cyclopedia of American Biography," 1: 213, 1887.
Anonymous, *Amer. Jour. Sci. and Arts,* 2d series, 16: 149, 1853.
March, Dr. Alden, Gross's "Amer. Med. Biography," 679–696, 1861.
Beck, L. C., *Amer. Jour. Sci. and Arts,* 10: 257–264, 1826; 11: 167–182, 1827; 14: 112–121, 1828.

for publication in your valuable journal. Those species which are presented as new are minutely described, and in all cases where the western specimens of known plants differ from the eastern, this difference is stated. By this means we shall become acquainted with, at least, some of the peculiarities in the vegetation of that interesting section of the United States. Concerning the more common plants, the habitats and times of flowering only are mentioned. The cataiogue, it is hoped will contribute somewhat to increase our stock of knowledge, and will be particularly interesting to geographical botanists, and to future writers upon the botany of the United States.

This annotated list, which was continued in three volumes of *Silliman's Journal,* mentions about two hundred species of plants, and is the earliest extensive list known to the writer. Many of Beck's plants are cited in Riddell's "Synopsis of the Flora of the Western States," published in 1835, but apparently only a portion of them are so mentioned.

In 1822 Beck moved back to Albany and remained there the rest of his life. He held positions as professor of botany and other sciences at a number of institutions up to the time of his death; Rensselaer Polytechnic Institute, Rutgers College and Albany Medical College being those with which he was most prominently connected. Dr. Beck was well known in botanical circles, being the author of a manual of the botany of the northern and middle states, of which two editions were issued. He also published a number of botanical papers. He was a well-known writer on chemical and medical subjects besides; and published a manual of chemistry which passed through four editions. He seems to have been a conservative writer, as his bibliography contains but twenty-three titles. Dr. Beck died at Albany on April 20, 1853.

After Beck closed his work in the vicinity of St. Louis there seems to have been a period of nearly ten years when there was no botanical work done. In 1831, however, there began a period of activity which has continued more or less regularly up to the present time. The first botanist to start this activity was Thomas Drummond.

(*To be continued*)

THE APPLICATION OF ZOOLOGICAL LAWS TO MAN[1]

By Professor WILLIAM RIDGEWAY, M.A., F.B.A., Lit.D., LL.D.

THIRTY years ago in this very city I heard for the first time a presidential address at the British Association, and I was singularly fortunate in entering on my novitiate. I had the privilege of hearing Professor Huxley deliver his presidential address to the embryo of that section over which I, a very unworthy successor, have this day the honor to preside. On that occasion Huxley dealt almost exclusively with the physical evolution of man, and the Neanderthal skull played an important part in his discourse. The anthropologists of that day and since have severely criticized, and rightly so, the old teleological doctrine that everything except man himself had been created for man's use, and they emphatically enunciated the doctrine that man himself has been evolved under the same laws as every other animal. Yet the anthropologists themselves have not always carried out in practise their own principles to their logical conclusions. To-day I shall attempt to show that the chief errors which impede the scientific study of man, which lead to the maladministration of alien races, and which beget blunders of the gravest issue in our own social legislation, are due in the main to man's pride in shutting his eyes to the fact that he is controlled by the same laws as the rest of the animal kingdom.

I. Let us first consider some of the chief problems which at present are being debated by the physical anthropologists. Foremost in importance of these is the stratification of populations in Europe. It has generally been held as an article of faith that Europe was first peopled by a non-Aryan race. Of course it is impossible for us to say what were the physical characteristics of paleolithic man, but when we come to neolithic man the problem becomes less hopeless. It has been generally held that the first neolithic men in Europe, whether they were descended or not from their paleolithic predecessors, had long skulls, but were not Aryan; that later on a migration of short-skulled people from Asia passed along central Europe and into France, becoming what is commonly termed the Alpine, by some the Ligurian, by others the Celtic race; that later these two primitive non-Aryan races were overrun by the Aryans, who, when these theories were first started, were universally considered to have come from the Hindu Kush, but

[1] Address of the president of the Anthropological Section of the British Association for the Advancement of Science, Dublin, 1908.

are now generally believed, as held by Latham, to have originated in upper central Europe. Yet, although the view respecting the cradle of the Aryans has changed, anthropologists have not seen the important bearing that it has upon the problem of neolithic man. The Aryans are generally held to have had a blond complexion.

As our discussion must from its nature concern itself with questions of race, let us first examine the criteria by which anthropologists distinguish one race from another. If you ask an anthropologist how he distinguishes an Aryan from a non-Aryan race, he will tell you that he relies on three main tests: (*a*) the color of the skin, hair and eyes; (*b*) the shape of the skull and certain other osteological characteristics; and (*c*) the system of descent through males. Formerly language was included in the tests of race, but when it was pointed out that the Negroes of Jamaica speak English, those of Louisiana French, henceforward it was assumed that one race can embrace the language of another with the greatest ease. Yet it may turn out, after all, that language was too hastily expelled from the criteria of race. On the other hand, we may find that too implicit faith has been placed on the three criteria of cranial characteristics, pigmentation and law of succession.

(*a*) As it is assumed that all Aryans were blond and traced descent through males, so it is held that all Europeans, who are dark-complexioned, and whose forefathers traced descent through women, are non-Aryan in race, and that, although they now in almost every case speak an Aryan tongue, this is not their primitive speech, but simply that learned from their Aryan conquerors. According to this orthodox view, the dark-skinned inhabitants of Italy, Spain and Greece are all non-Aryan, and all have borrowed the language of their masters, whilst, of course, the same is held respecting the melanochrous population of France and of the British Isles. Ever since Professor Sergi comprehended under what he terms the "Eurafrican species" all the dark-complexioned peoples of southern and western Europe, as well as the Semitic and Hamitic peoples of western Asia and northern Africa, the doctrine that the dark-skinned peoples of Europe once spoke a non-Aryan tongue or tongues is supposed to have been finally established. But under his Eurafrican species Sergi includes the blond race of northern Europe who speak Aryan languages along with the dark races who speak non-Aryan tongues. It is argued that as all the dark-skinned peoples on the north side of the Mediterranean belong by their physical type to the same original stock as the Semites and Hamites, they must likewise have spoken non-Aryan languages. Yet it might as well be maintained that the Finns, who speak a non-Aryan tongue, and the Scandinavians, who speak an Aryan, were originally all of one stock, because both races are blond.

This doctrine of a Mediterranean race depends upon the tacit assumption made by the physical anthropologists that identity or similarity of type means identity of race. Yet this assumption does not bear the test of scientific examination, for it assumes that only those who are sprung from a common stock can be similar in physical structure and coloration, and it leaves altogether out of sight the effects of environment in changing racial types, and that, too, in no long time. The change in the type of the American of New England from that of his English ancestor and his approximation to the hatchet face and thin scraggy beard of the Red Indian have long been remarked, whilst the Boers of South Africa, in less than 150 years, have quite lost the old Dutch build, and become a tall weedy race. The effects of climatic conditions are very patent amongst the native peoples of the New World. The Iroquois of the temperate parts (lat. 40°–45°) of North America were a tall, rather light-complexioned race, but as we keep moving south and approach the equator, their kindred tribes grow somewhat darker in complexion and more feeble in physique, except where they live at a considerable altitude, for of course altitude acts in the same way as latitude. When once we pass below the equator the physique keeps steadily improving until we come to the Pampas Indians, a vigorous race who defied all the efforts of the Spaniards to subdue them; and finally we meet the Patagonians (lat. 40°–53°), a fine, tall, light-complexioned race, who form in the south the counterpart of the Iroquois and their closely allied tribes in the north.

The same law, as is well known, can be seen at work in Europe. Starting from the Mediterranean, we meet in the lower parts a melanochrous race; but gradually, as we advance upwards, the population as a whole is growing less dark, until finally, along the shores of the Baltic, we meet the tallest and most light-complexioned race in the world. Of course it has been explained that the change in pigmentation, as we advance from south to north, is due to the varying proportions in the admixture of the blond race of the north with the melanochrous of the south. But it is difficult to believe that the movements up or down of the people from the southern side of the Alps, or of those from the shores of the Baltic, have been so nicely proportioned as to give the general steady change from north to south in coloration without the aid of some other force. The case of America, which I have just cited, is in itself enough to raise a suspicion that climatic influences are at work all the time, and that environment is in reality the chief factor in the variation of both stature and pigmentation from the Mediterranean to the Baltic. The white race of the north is of the same proximate ancestry as the dark-complexioned peoples of the northern shores of the Mediterranean. I have already argued elsewhere that, as the ice-sheet receded, mankind kept pressing farther north, and gradually under changed climatic conditions the type changed from area to area, and they all still continued to speak the same Indo-European tongue, but with dialectic variations, these also being no doubt due to the physical changes in the vocal organs produced by environment.

If we turn from man to the other animals we find a complete demonstration of this doctrine. For instance, the conditions which have produced a blond race on the Baltic have probably produced the white hare, white bears, and the tendency in the stoat and the ptarmigan to turn white in winter, whilst in the same regions of Europe and Asia the indigenous horses were of a dun color, who not only turned white in winter, but had a great tendency to turn white altogether. It may be objected that the Lapps and Eskimo are not tall and blond, but, on the contrary, short and dark; but they live within the arctic circle in regions where the sun does not shine at all for a great part of the year, and consequently they are quite outside the conditions of environment under which the tall blond race of North Germany has long dwelt. Of course, in dealing with man we are always confronted with the difficulties arising from his migrations; but if we can find a family of lower animals who can not be said to have thus migrated, and who show the effects of environment, we shall be able to argue powerfully from analogy.

The horse family supplies the example required. If we follow it from northern Asia to the Cape of Good Hope, we shall find that every belt has its own particular type, changes in osteology as well as in coloration taking place from region to region. First we meet the old dun horse, with its tendency to become white, the best European examples of which were probably the now extinct ponies of the Lofoden Isles. In Asia, Prejvalsky's horse is the best living instance—a dun-colored animal with little trace of stripes. Bordering on the Prejvalsky horse, or true tarpan, come the Asiatic asses: first the dzeggetai of Mongolia, a fawn-colored animal, the under parts being Isabella-colored; then comes the kiang of the Upper Indus Valley, seldom found at a lower altitude than 10,000 feet, rufous brown with white under parts, whilst, as might be expected from its mountain habitat, its hind quarters are much more developed in length and strength than in the asses of the plains. The *Onager indicus, onager* and *hemippus* are found in all the great plains of the Punjab, Afghanistan, western India, Baluchistan, Persia and Syria, whilst a few are said to survive in South Arabia. All these are lighter in color than the kiang, the typical onager being a white animal with yellow blotches on the side, neck and head. All the Asiatic asses are distinguished by the absence of any shoulder stripe, though they occasionally show traces of stripes on the lower parts of the legs. The southern Asiatic asses just described in their grayer color and smaller hoofs approximate to the wild asses of Africa, especially to those of Somaliland, whilst it is maintained that in their cry, as well as in their color, the kiang and dzeggetai come closer to the horse, whose next neighbors they are.

Passing to Africa, we find the ass of Nubia and Abyssinia showing a shoulder stripe, and frequently with very strongly defined narrow stripes on the legs, the ears being longer than those of the onager. But in closer proximity to southwestern Asia comes the Somali ass, which differs from those of Nubia and Abyssinia by being grayer in color, by the entire absence of shoulder stripes and by smaller ears, in all which characteristics it comes closer to its neighbors on the Asiatic side than it does to its relations in Abyssinia and Nubia.

Next we meet the zebras. First comes the magnificent Grévy zebra of Somaliland, Shoa and British East Africa. It is completely striped down to its hoofs, but the coloration of the specimens from Shoa differs from that of those from Somaliland, and from those of British East Africa. The Grévy zebra has its hoofs rounded in front like those of a horse, but its ears are more like its neighbors, the asses, than those of any other zebra.

In the region north of the river Tana the Burchelline group of zebras overlaps the Grévy, and though it differs essentially in form, habits and shape of its hoofs from the Grévy, some of those in the neighborhood of Lake Barringo show gridiron markings on the croup like those on the Grévy zebra, whilst, like the latter, they also possess functional premolars.

All the zebras of the equatorial regions are striped to the hoofs, but when we reach the Transvaal, the Burchelline zebra, known as Chapman's, is divesting itself of stripes on its legs, whilst the ground color is getting less white and the stripes less black. Farther south the true Burchell zebra of the Orange River has completely lost the stripes on its legs and under surface, its general coloring being a pale yellowish brown, the stripes being dark brown or nearly black. South of the Orange River the now extinct quagga of Cape Colony had not only begun to lose the stripes of its under part and on the hind quarters, but in Daniell's specimen they only survived on the neck as far as the withers, the animal having its upper surface bay and a tail like that of a horse, whilst all specimens of quagga show a rounded hoof like that of a horse.

In the quagga of 30°–32° S. we have practically a bay horse corresponding to the bay Libyan horse of lat. 30°–32° N.

But the production of such variations in color do not require great differences in latitude. On the contrary, from a study of a series of skins of zebras shot for me in British East Africa, each of which is from a known locality and from a known altitude, there can be no doubt that such variations in color are found from district to district within a comparatively small area.

In addition to the two species of zebra already mentioned, there is the mountain zebra, formerly extremely common in the mountainous parts of Cape Colony and Natal, though now nearly extinct in that area. Its hind legs, as might naturally have been expected from its habitat, are more developed than those of the other zebras, just as these same limbs are also more developed in the kiang of the Himalayas than in any other ass.

With these facts before us, there can be no doubt that environment is a most potent factor not only in coloration, but also in osteology. No less certain is it that environment is capable of producing changes in animal types with great rapidity. Thus, although it is an historical fact that there were no horses in Java in 1346, and it is known that the ponies now there are descended from those brought in by the Arabs, yet within five centuries there has arisen a race of ponies (often striped) some of which are not more than two feet high. Darwin himself has given other examples of the rapid change in structure of horses when transferred from one environment to another, as, for instance, when Pampas horses are brought up into the Andes.

Another good example is that of the now familiar Basuto ponies. Up to 1846 the Basutos did not possess a single horse, those of them who went down and worked for the Boers of the Orange River usually taking their pay in cattle. At the date mentioned some of them began to take horses instead. These horses were of the ordinary mixed colonial kinds, and we may be sure that the Boers did not let the Basutos have picked specimens. The Basutos turned these horses out on their mountains, where, living under perfectly natural conditions, their posterity within less than forty years had settled down into a well-defined type of mountain pony.

Nor is it only in the horse family that we meet with examples of the force of environment. The tiger extends from the Indian Ocean, through China up to Corea, but the tiger of Corea is a very different animal from that of Bengal. Instead of the short hair of the Indian tiger the Corean has clothed himself with a robe of dense long fur to withstand the rigors of the north. It is not unlikely that if we had a sufficient number of skins from known localities we could trace the change in the tiger from latitude to latitude, just as I have shown in the case of the Equidæ.

Now whilst there is certainly a general physical type common to all the peoples round the Mediterranean, it by no means follows that all those peoples are from the same original stock. On the contrary, the analogy from man in other parts of the world, as well as that of the Equidæ, suggests that the resemblance between the Berbers, who speak

Hamitic, the Greeks, who speak Aryan, and the Jews and Arabs, who spoke Semitic, is simply due to the fact that those peoples, from having long dwelt under practically similar conditions in the Mediterranean basin, have gradually acquired that physical similarity which has led Sergi to the assumption that they have a proximate common ancestry, and that they accordingly form but a single race.

Nor is there any lack of instances of convergence of type under similar conditions in the case of the lower animals. We saw that the asses of southwestern Asia approximate in color to the asses of northeast Africa, and in respect of the size of the ears and absence of shoulder stripe, more especially to the nearest of these, the ass of Somaliland. Yet it does not follow that they are more closely related to the Somali ass than they are to their own next neighbors, the kiang. On the contrary, it is much more likely that the Somali ass is closely related to those of Abyssinia, and that the southwestern Asiatic asses are closely related to the kiang. The approximation in color, absence of shoulder stripe and size of the ears between the asses of Somaliland and those of southwestern Asia must rather be explained by a convergence of types under the somewhat similar climatic conditions of Somaliland and the nearest parts of southwestern Asia. Again, though there are very strong, specific differences between the Grévy and Burchelline zebras met in the neighborhood of Lake Barringo, there is a curious approximation, not only in marking, but also in the teeth between these two species, which is best accounted for by supposing that it is the outcome of similar environment. It may be said that this approximation may be due to the interbreeding of the two species of zebras in the region where they overlap. This, in itself a most unlikely contingency from all that is known of the habits of wild species, certainly can not be alleged in the case of the convergence in type between the asses of southwestern Asia and the Somali ass, since they are separated by the Red Sea and the Persian Gulf.

Again, the representative of the crocodile family in the Ganges is distinguished by the extreme elongation of the head and jaws, whilst the same elongation of the head is equally characteristic of the representative of the dolphin family found in the same waters. Again, all through the Indian Ocean wherever any family of crabs have become inhabitants of coralline sands its members have long legs. Again, it has long been noticed that in Cutch all the larger animals have a tendency to become a sandy color, whilst in certain areas of South America insects, no matter to what family they belong, have a tendency to one common aspect.

It may, of course, be said that the changes in color of the horse family, tigers and insects are for "protective" reasons. But the case of the horse family alone is sufficient to dispose of this objection.

The kiang of the Himalaya had no dangerous enemy until man was armed with a rifle. In Africa the zebras have had only two formidable foes—man and the lion. It is asserted by the most experienced hunters that the gaudy livery of the zebra makes him conspicuous from afar, whether he is on the mountain, on the plain or in the shade of a tree. His brilliant color, therefore, really exposes him to man. But it will be said that it is well adapted to conceal him at night, at which time the lion seeks his prey. Yet as the best authorities hold that the lion hunts entirely by scent, the coloration of the zebra affords him no protection against his inveterate foe.

I have shown that in horses the colors—such as bay, black, gray and white—accompany certain well-defined inward qualities. But as black is most certainly not a primitive horse color, it follows that coat colors may be intimately connected with certain other characteristics quite irrespective of protective coloring. Again, as the variation in the size and shape of the ears and hoofs of the asses and zebras can not be set down to protective coloring, but must be due to other causes, there is no reason why variations in color should not be ascribed to similar causes.

The argument based on the analogy of the horse family and the tigers, and on that of the natives of the New World, may be applied to the races of Africa. Next to the Mediterranean lie the Berbers and their Hamitic congeners, who are regarded as part of the Eurafrican species by Sergi and his school. But the Berbers are not all of the typical Mediterranean physique. The blond Berbers of the highlands of Rif in Northwest Morocco and of the Atlas have long been well known. In the region lower down and in western Tunis the occurrence of the xanthochrous type seems much less frequent, whilst farther east it practically disappears.

It is certain that there was a fair-haired element in Libya long before Rome conquered Carthage or the Vandals had passed into the ken of history. Callimachus testifies to the existence of blond Berbers in the third century B.C. We may hold, then, with Sergi and others that the blond element in the Berbers is not a survival from invasions of Vandals or Goths, or from Roman colonists, but that they rather owe their fair complexions and light-colored eyes to the circumstance that they were cradled in a cool mountainous region, and not along the low-lying border of the Mediterranean like their dark-colored relations whose language and customs they share.

If, then, some of those who speak Hamitic are fair, and have been fair for centuries before Christ, as Sergi himself admits, whilst others are dark, there is no reason why some of the peoples who speak Aryan might not be dark whilst others are blond.

The Berbers and their Hamitic congeners shade off on the south into other peoples, but this is not altogether due to intermarriage, as is commonly held, for it is more probably to be explained as due in a large part to climatic conditions. The Bantus, who are said to have originated in the Galla country and to have spread thence, are now regarded by the chief authorities as the result of an intermixture of Hamites and Negroes. But, on the grounds I have already stated, it is more rational to regard them as having been evolved in the area lying between the Hamitic peoples on the north and the Negroes on the south, just as we have corresponding types of the horse family in Nubia and Abyssinia and in the equatorial regions. The same hypothesis also explains the existence of those cattle-keeping tribes which lie west of the Nile, stretching across northern Nigeria, who border on the Berbers, but yet differ from them, and border also on the Negroes, but differ from them likewise. South of these tribes come the Negroes, the true children of the equator. The Bantu is able to live in elevated equatorial areas, and he has burst his way down to the subtropical and temperate parts of South Africa, where he especially flourishes in the highlands, thus showing that his race was originally evolved under similar conditions. The Bantu found in the south the Hottentots, who are especially distinguished by steatopygy, a feature which has led some to identify them with the primitive steatopygous race supposed to have once lived in southern Europe, Malta and North Africa, and to have left evidence of their characteristic in their representations of themselves. But, granting that such a race once lived in North Africa and southern Europe, there is really no more reason for supposing that they and the Hottentots formed one and the same race than there is for assuming that Daniel's quagga, which was practically a bay horse, was proximately akin to the bay horse of North Africa. The occurrence of steatopygy in two areas so wide apart is not due to an ethnical migration, but rather to similar climatic conditions producing similar characteristics.

As some anthropologists so commonly explain the origin of races such as the Bantus by intermarriage, it may be well to see whether intermarriage between two races, one of which is an invader, is likely to produce a permanent effect upon the general physique of a whole community. I have shown elsewhere that the many invasions of fair-haired races into the three southern peninsulas of Europe and into the Ægean islands have left no permanent trace on the population. It is a matter of common knowledge that the offspring of British and native parents in India have a constant tendency to die out. The same undoubtedly holds true for the offspring of British soldiers serving in Egypt, the Soudan and West Africa. The native race always reasserts itself. In America the Spanish blood has died out, or is dying out, everywhere except in the temperate regions of Chile, Quito and Argentina, where the descendants of the Spanish settlers thrive in a climate very analogous to that of Spain. In the southern states of North America the whites can not flourish, and only just manage to survive. On the other hand, the descendants of the Negro slaves imported into Brazil, the West Indies and the southern states of North America thrive and multiply with extraordinary vigor; a fact doubtless due to their race having been evolved under similar conditions in equatorial Africa.

Even from the evidence already to hand there is high probability that intermarriage can do little to form a new race unless the parents on both sides are of races evolved in similar environments.

I have already pointed out that although the fair-haired race of upper Europe has age after age kept pouring over the Alps into Italy and the other southern peninsulas, and has constantly intermixed with the indigenous populations, it is only in the upper part of Italy that the blond race is able to hold its own. In Italy the xanthochrous race in ancient times, as to-day, had its maximum along the Alps, and gradually dwindled towards the south until the melanochrous race stood practically alone in the lower part of the peninsula. So too in the Balkan, whilst the fair-haired element was at its maximum along the Alps and the Danube, southwards the melanochrous becomes more and more completely dominant, as it practically is to-day in the lower part of the peninsula.

(*b*) In the Alpine regions there has been from Neolithic times a brachycephalic race, also found in central France and in the British Isles, whither it is supposed to have come in the Bronze age. It has been a fundamental article of faith with Sergi and others that this round-headed race came from Asia, the home of brachycephalism. It is Mongolian according to most, and spoke a non-Aryan language; but Sergi regards it as Aryan, thus reverting to the old doctrine, which made the Aryans come from central Asia, and he assumes that these invaders imposed their language both on the aborigines of Italy, such as the Ligurians, and on the blond race of northern Europe; but we shall soon see that this assumption has no base. Now, as these folk dwelt in the region where we find the Ligurians of historical times, others have argued that the Ligurians were a non-Aryan people from Asia. But it is impossible to find any hard-and-fast lines between the Alpine race and the peoples north and south of it in culture and sociology. For that reason, when treating of the people of the Alps in my "Early Age of Greece" I did not take any account of the difference in cranial measurements. In 1906, at the British Association, I maintained that this difference of skull type did not mean any racial difference, and on the analogy of the changes in the osteology of the Equidæ I urged that the roundness of the skulls was simply due to environment, as the horses of the Pampas when brought up into the mountainous regions of Chile and Peru rapidly change their physical type. Physical anthropologists have already maintained that the round head of the Mongolian has been developed in the high altitude of the Altai. If that be so, there is no reason why a similar phenomenon should not have taken place in the Alpine region, in Albania, Anatolia and wherever else in mountain areas brachycephaly has been found in more than sporadic examples, which, of course, may well be due to migrations or importation of slaves. But I am far from suggesting that altitude is the only cause of brachycephaly.

The evidence, then, as far as it goes, points to the same conclusion as that to which we came as regards pigmentation, and it may eventually be proved that just as each area has its own type of coloration, so also has it its own osteological character. In support of this I may point out that recently Dr. William Wright, Hunterian lecturer, has come to the conclusion from his craniological investigations that the brachycephalic Alpine race was evolved on European soil, whilst Dr. C. S. Myers has been led by his researches on Egyptian skulls to conclude that, "in spite of the various infiltrations of foreign blood in the past, modern Egypt contains a homogeneous population which gradually shifts its average character as we proceed southwards from the shores of the Mediterranean to Nubia beyond the First Cataract."

It is not impossible that Alpine environment may have acted upon the shape of the skull of the ox as well as that of man. We know from the examination of the fauna of the lake dwellings of Switzerland that the Celtic ox (*Bos longifrons*) was there the common type, and its descendants still continue to be the typical breed along the Alpine chain. This ox is characterized by its strongly developed occipital region and its small horns curved forward and inward. As it differs so essentially from the urus (*Bos primigenius*) and from the long-horned cattle of the Mediterranean lands, it seems not unlikely that the peculiar cranial formation may have been evolved under mountainous environment.

It is now clear that differences in the shape of the skull and in the color of the skin, hair and eyes can not be at all implicitly relied on as criteria of race. The defenders of the non-Aryan character of the dark races of Greece, Italy, Spain, France and the British Isles have now to depend on two arguments only, one of which is linguistic, the other sociological. It is admitted that it is very difficult to point to any non-Aryan survivals in the vocabularies of the languages of these countries, and it is also admitted that in them all the tense system of the Aryans has been taken over in its entirety. Neither Kretschmer nor any one else has ventured to affirm that there is any survival of non-Aryan syntactical forms in Greek, the language of all others in which the Ayran tense system is found in its greatest delicacy and perfection. But we know that in all cases where an Aryan language has without doubt been adopted by a non-Aryan folk the tense system is invariably broken up. No better example than this is needed than ordinary "pigeon" English. So difficult is it for the defenders of the non-Aryan theory of the origin of the aborigines of Greece to maintain their position that one of the latest, Professor Burrows, has to rely on certain supposed syntactical survivals of a non-Aryan language which Sir John Rhys believes that he has found in Welsh and Irish, and in the remarkable resemblance which Professor Morris Jones thinks that he has traced between the syntax of those languages and that of Berber and ancient Egyptian.

Yet when we examine the evidence on which Sir John Rhys relies, it turns out to be only three Welsh and Cornish oghams, written not in pure Celtic, but in dog Latin, and also two Irish oghams, which show a looseness in the use of the genitive suffix at a time when final syllables were dropping out of use in Irish. Sir John Rhys supposes that the non-Aryan inhabitants of these islands derived their Gaelic speech from a people whom he terms Celticans, who spoke Goidelic, and who were followed by the Brythons, who found the aborigines already Celticized. Professor Morris Jones freely admits that the aborigines must have borrowed the full Aryan tense system, a fact in itself sufficient, from what I have already said, to arouse grave suspicions as to the validity of any arguments based on supposed fundamental grammatical differences. But this supposed taking over of the full Aryan tense system by the non-Aryan aborigines of these islands is rendered all the more miraculous from the circumstance that Sir John Rhys holds that his Celticans, who spoke Goidelic, "came over not later than the great movements which took place in the Celtic world of the continent in the sixth and fifth centuries before our era," that the Brythons "came over to Britain between the time of Pytheas and that of Julius Cæsar," and that the Brythons were not likely to come into contact on any large scale with the aborigines "before they had been to a considerable extent Celticized." It is thus assumed that it was possible for the aborigines to have been so completely Celticized as to have adopted the Aryan tense system, as well as the Aryan vocabulary, in its fullness in the interval between the sixth or fifth century and the second century B.C. Yet English has been the master speech in Britain for many centuries, and that, too, when reading and writing have been commonly practised; yet Gaelic still survives, whilst Welsh not only survives but flourishes. It is, therefore, simply incredible that such a complete transformation as that postulated could have taken place in three or four centuries in an age when writing and literature can be hardly said to have existed in these islands.

Let us now see under what conditions does one race or people borrow the language of another. Slaves, of course, take over the language of their masters, but we have to consider (1) the adoption by a conquering people of the language of the conquered, (2) the adoption by a conquered people of that of their conquerors, and (3) the adoption by a people themselves unconquered of the language of their neighbors. Under what conditions do the conquerors adopt the language of the conquered? Ireland affords us at least two certain examples. Cromwell planted large bodies of his English soldiers in Tipperary, but they had no English women, and therefore took as wives the daughters of the land, who spoke the Irish language. From this union resulted a splendid offspring, who spoke chiefly the language of their Irish mothers, and not their fathers' English. So it came to pass that in a single generation the progeny of Cromwell's Puritans were in language as Irish as the purest-blooded aboriginal of Munster. Yet this adoption of the Irish language by the great majority of the children of these settlers took place in spite of the effect which the reading of books in English must have exerted to counteract the tendency to adopt the Irish language. Let us go back five hundred years in Irish history and we find exactly the same process going on. The Normans who followed Strongbow into Ireland, like their captain, frequently married native women. It is a matter of common knowledge that the Anglo-Norman settlers in a short time became *Hiberniores ipsis Hibernis.*

These and other examples too numerous to cite here prove that the children of bodies of conquerors who marry the women of the land will have an inevitable tendency to follow their mothers' speech. We may also lay down as a solid factor in the tendency of the conqueror to merge into the conquered the isolation of the conquerors from their original homes and from the great mass of those who speak the same language.

Next we come to the case where the conquerors bring with them some women of their own race. This of course helps to keep their own language alive, as a certain number of the children speak it as their mothers' tongue. But even in these circumstances the invaders are liable to drop their own language and practically adopt that of the natives. Thus the Northmen who settled on the coast of France gradually abandoned their national tongue for French, though modifying dialectically their adopted language. When under the name of Normans they conquered and settled in England, they again adopted the language of the conquered, though modifying the English tongue by many words and phrases brought with them from Normandy, and we have just seen how some of their descendants who settled in Ireland for the third time changed their speech for that of the conquered.

Hitherto all our examples show the adoption by the conquerors of the language of the conquered, even when they bring a certain number of their women with them.

We now come to undoubted cases where the language of the conqueror has been able to get a firm foothold. From the time of the plantation of Ulster, the advance of the English tongue, and consequent decadence of the Irish, has steadily proceeded, for the settlers, unlike Cromwell's Ironsides, brought with them women of their own race and speech. Consequently their children grew up speaking English as their mothers' tongue. Yet even with such a basis the advance of English amongst the Irish has been exceedingly slow. In the glens of Antrim the Irish language still lingers on, whilst in Donegal, Connaught, Kerry, Cork and Waterford, English has not succeeded in ousting completely the native language, though the former is the language of the national schools, of the newspapers and of trade.

The story of the establishment of English itself in Britain is just the same as in Ulster. We know from Bede that the Angles who settled in Britain left Holstein in large bodies, bringing with them their wives and families, and leaving their old homes without inhabitant. Having thus settled in solid masses in the east of Britain, they retained fully their own tongue, impressed it upon their menials, and gradually, as they extended their conquests westward over the island, English became the language of the land. Yet in Wales the ancient speech still flourishes.

We may, therefore, conclude that the adoption by the conquered of the language of the conqueror, even when it does take place, which is but rarely, is a very slow and tedious process, although every advantage is on the side of the invading tongue, and that when the native speech gets a fair field, as in Wales, the language of the conqueror can make little or no advance.

Only the third possibility now is left—that one people can adopt without conquest the language of another. But no example of such can anywhere be found, although Europe presents numerous instances to the contrary. There can be no stronger case than that of the Swiss Republic, in which peoples with more than four kinds of language combine for national defense and other advantages. Here, if anywhere, we ought to find a gradual adoption by certain cantons of the language of their neighbors. But, far from this being so, the German, French, Roumansch and Italian cantons rigidly preserve their respective mother-speeches. In the Austro-Hungarian Empire there is no tendency observable on the part of either Magyars or Slavs to adopt German; nay, the very opposite is the case. Again, the Finns have not adopted either Swedish or Russian, though partitioned between their more powerful neighbors.

To sum up, it seems that no nation readily adopts the language of another, even though it be in close ties of friendship; whilst there is still less tendency when national hostility intervenes. Secondly, the adoption of the language of the conqueror by the conquered, except under the most favorable circumstances, is not common, and only takes place by a very gradual process, as is seen in the case of Ireland. Thirdly, there is a strong tendency for the conqueror to adopt the language of the conquered, as was done by the Normans in England, In Ireland, in Sicily and in Italy; by the Cromwellian settlers in Tipperary, by the Bulgari in Bulgaria, by the Franks in Gaul, by the Lombards in Italy and by the Visigoths in Spain. There is thus an inevitable tendency for the children to speak their mothers' tongue, and indeed the phrase "mother-tongue" is based on the fact observed through long ages that the child learns its first words from its mother and thus takes after her in speech. This law, which still holds good in modern days and in civilized communities, must have been far stronger in earlier times in countries where the tie of marriage hardly existed and the child belonged to its mother's and not its father's tribe, as is still the case in many parts of the world.

In view of these facts we can not accept Sir John Rhys's hypothesis that when a few bodies of invaders, whom he terms Celticans, passed into Ireland the indigenous supposed non-Aryan race within two centuries completely abandoned its own language, taking over in its entirety the Aryan tense system as well as the Aryan vocabulary of its conquerors.

Now let us turn to Greece, Italy and Spain. It is admitted that neither Arcadia nor Attica was ever conquered by Acheans or Dorians, yet in both these areas the Greek language existed through all historical time, and in Attica especially the Aryan tense system is found in its highest perfection. The dialect of Arcadia can not have been taken over from Acheans or Dorians, because it is the same as that of the Cypriotes from Arcadia who settled in Cyprus at least 1100 B.C. It is also very close to the dialect of Pelasgiotis in Thessaly, the home of the aboriginal Pelasgian population, whilst it comes closest of all Greek dialects to that of the ancient Epic. There can, therefore, be no doubt that Arcadian is no mere bastard lingo, half non-Aryan, half Aryan, but is the genuine speech of the oldest and most unmixed population of Greece, who were undoubtedly a melanochrous race, and who also most certainly had occupied Greece from the Stone age.

The Ligurians, who formed from the Stone age the bottom stratum in all upper and central Italy, are now admitted to have spoken an Aryan language, and I have recently given some reasons for believing that the Latin language is simply the native tongue of the aboriginal Ligurian population of Latium with some admixtures derived from the Italic tribes of Siculi and Sabines. I have also shown that the ancient

Iberians, the next neighbors of the Ligurians, used the same forms of place-names as the latter, and that some of the words plainly exhibit Aryan terminations. Thus we may conclude that with the exception of the Basques, who are probably a non-Aryan spurt from North Africa, the melanochrous populations of Spain, Italy, the Balkan Peninsula, France, Britain, Ireland and Holland have from the first spoken none but an Aryan language.

(*c*) Only one argument is now left to the defenders of the non-Aryan theory. When the study of sociology first sprang up in the last century, it at once became a fundamental doctrine that the Aryans had always been strictly patriarchal, and that polyandry and descent through women was unknown amongst them. Though this view has received many rude shocks in later days, Professor Zimmer argues from it that the indigenous people of Britain and Ireland were non-Aryan.

It is well known from the ancient writers that the Picts were polyandrous and that succession was consequently through females. Again, it is certain, both from the ancient Irish literature and also from statements of external writers, that the Irish were polyandrous, and that they also almost certainly traced descent through women. Accordingly, Professor Zimmer infers that the indigenous race was non-Aryan. But McLennan has long since pointed out that descent through women was the ancient law at Athens, and I have just shown that the Athenians and Arcadians, the autochthonous, dark-complexioned people of Greece, never spoke any save an Aryan tongue. Moreover, I have shown elsewhere that the Ligurians, who are now generally admitted to have spoken always an Aryan language, had descent through women, whilst I have also pointed out that there is good evidence that the ancient Latins, who have generally been taken as typical Aryans, had the same system. Again, it is admitted that the ancient Illyrians and dark-complexioned Thracians spoke an Aryan language, which, inasmuch as it differed materially in certain ways from that spoken by their Celtic overlords, must have been aboriginal, whilst I have further given grounds for believing that the ancient Iberians (though not the Basques) were also an Aryan-speaking folk. But there is good evidence that the Illyrians, melanochrous Thracians and Iberians all traced descent through women. In view of these facts it is useless to urge that because the Picts of Scotland and the ancient Irish had that system of succession through females these peoples must have been non-Aryan.

We have now reviewed the three main criteria of race at present used by anthropologists: (*a*) pigmentation of the skin, hair and eyes; (*b*) the shape of the skull and other osteological characteristics; and finally, (*c*) their system of tracing descent. We have seen that osteological differences may be but foundations of sand, because it is certain that such variations take place within very short periods, not only in the case of the lower animals, as in the horse family, but in man himself. Pigmentation is no true criterion, for we have found a steady tendency to change in color in the case of the lower animals from latitude to latitude, whilst in the case of man the steady shading off in color from dark to blond may be traced from the equator to the Baltic. Unless, then, we postulate that man is entirely free from the natural laws which condition the osteology and pigmentation of other animals, we must admit that neither bone nor color differences can be regarded as crucial criteria. Further, we saw that the test of descent through males or females broke down absolutely in the case of peoples who can be proved historically never to have spoken any but a non-Aryan language. Finally, we are forced to the conclusion that language, now that we realize what are the laws which govern its borrowing by one race from another, is really the surest of all the known tests of race when dealt with broadly and over wide areas, and not merely in the way of guesswork etymologies.

II. Hitherto I have dealt only with the need of a rigid application of zoological laws in studying the evolution of the various races of man. In the time that is still left I propose to touch briefly on the vast importance of such natural laws when dealing with the native races of our great dependencies and colonies, and in our own social legislation. I venture to think that the gravest mistakes which at present are being made in our administration and legislation are due to the total disregard of the natural laws, which not only modify and differentiate one race from another, but also are constantly producing variations within our own community. As physical characteristics are in the main the result of environment, social institutions and religious ideas are no less the product of that environment. Several of our most distinguished Indian and colonial administrators have pointed out that most of the mistakes made by British officials are due to their ignorance of the habits and customs of the natives. It has been in the past an axiom of British politicians that in the English Constitution and in English law there is a panacea for every political and social difficulty in any race under the sun. Only let us give, it is urged, this or that state a representative parliamentary system and trial by jury and all will go well. The fundamental error in this doctrine is the assumption that a political and legal system evolved during many centuries amongst a people of northwestern Europe, largely Teutonic, and that, too, living not on the mainland but on an island, can be applied cut and dried to a people evolved during countless generations in tropical or subtropical regions, with social institutions and religious ideas widely different from those of even South Europeans, and still more so from those of northern Europe. We might just as well ask the Ethiopian to change his skin as to change radically his social and religious ideas. It has been shown by experience that Christianity can make but little headway amongst many peoples in Africa or Asia, where, on the other hand, Muhammadanism has made and is steadily making progress, acting distinctly for good, as in Africa, by putting down human sacrifice and replacing fetish worship by a lofty monotheism. This is probably due to the fact that Muhammadanism is a religion evolved amongst a Semitic people who live in latitudes bordering on the aboriginal races of Africa and Asia, and that it is far more akin in its social ideas to those of the Negro or Malay than are those of Christianity, more especially of that form of Christianity evolved during the last twelve centuries by the Teutonic peoples of upper Europe, who are of all races farthest in physical characteristics, in religious ideals and social institutions, from the dark races of Africa and Asia. This great gulf is due not merely to shallow prejudice against other people's notions; it is as deep-seated as is the physical antipathy felt by the Teuton for the Negro, which is itself due to the very different climatic conditions under which both races have been evolved. The Teuton does not freely blend with the black, and even when he does intermarry he treats his own half-bred progeny with contempt, or at most with toleration. On the other hand, some south Europeans—for example, the Portuguese—are said to have little objection to intermarrying with dark races and allowing the mixed progeny an equal social status, whilst the Arab through the ages has freely taken to wife the African, and has never hesitated to treat the hybrid offspring as equals. There is thus a wide breach between the physique and the social and religious ideas of the African and our own; but, as political and legal institutions are indissolubly bound up with social and religious, it follows inevitably that the political and legal institutions of a race cradled in northern Europe are exceedingly ill adapted for the children of the equator. Accordingly, in any wise administration of these regions it must be a primary object to study the native institutions, to modify and elevate them whenever it may be possible, but never to seek to eradicate and supplant them. Any attempt to do so will be but vain, for these institutions are as much part of the land as are its climate, its soil, its fauna and its flora. "Naturam expellas furca, tamen usque recurret." Let us hope for a successful issue for the effort now being made by the Royal Anthropological Institute to establish an Imperial Bureau of Anthropology whose function will be not only to carry out systematically the scientific study of man, but also to aid the administrator and the legislator, the merchant and the missionary.

III. I now pass to my last and most important topic—natural laws in relation to our own social legislation. We have seen that environment is a powerful factor in the differentiation of the various races of man, alike in physique, institutions and religion. It is probable that the food-supply at hand in each region may be an important element in these variations, whilst the nature of the food and drink preferred there may itself be due in no small degree to climatic conditions. Each zone has its own peculiar products, and beyond doubt the natives of each region differ in their tastes for food and drink. The aboriginal of the tropics is distinctly a vegetarian, whilst the Eskimo within the arctic circle is practically wholly carnivorous. In each case the taste is almost certainly due to the necessities of their environment, for the man in the arctic regions could not survive without an abundance of animal fat. It is probable that the more northward man advanced the more carnivorous he became in order to support the rigors of the northern climate. The same holds equally true in the case of drink. Temperance reforms would enforce by legislation complete abstinence from all alcoholic liquors, and they point to the sobriety of the Spaniards, Italians and other South Europeans, and urge, if these nations are so temperate, why should Britons and Irish continue to drink beer and spirits in such large quantities? This appeal depends, unfortunately, on the false assumption that the natives of these islands enjoy the same climate as the people of the sunny south. All across northern Europe and Asia there is a universal love of strong drink, which is not the mere outcome of vicious desires, but of climatic law. In Shakespeare's time "your Englishman was most potent in potting," and this was no new outbreak of depravity, for the earliest reference in history to the natives of these islands tells the same tale. When Pytheas of Marseilles traveled in these regions, about 350 B.C., he found the people making "wine from barley," and, though he does not explicitly say so, we need not doubt that it was meant for home consumption. In view of these facts we must regard this tendency as essentially climatic. This view derives additional support from the well-authenticated fact that one of the chief characteristics of the descendants of British settlers in Australia is their strong teetotalism. This can not be set down to their having a higher moral standard than their ancestors, but rather, as in the case of Spaniards and Italians, to the circumstance that they live in a country much warmer and drier than the British Isles. We must, therefore, no matter how reluctantly, come to the conclusion that no attempt to eradicate this tendency to alcohol in these latitudes can be successful, for the most that can be done by the philanthropist and the legislator is to modify and control it, but especially by moral means.

I have spoken of the principles at work in the differentiation of one race from another. It may be that the same principles or others closely allied may be at work within each community, for each community is but the whole world writ small. Within the United Kingdom itself there are not only different physical types, but very different ideas respecting marriage and divorce embodied in the laws regulating those fundamental institutions in England, Scotland and Ireland. If such fundamental differences exist in that most important of social institutions, we may well expect that the natural laws which differentiate one race from another may be at work within every community in the United Kingdom.

Yet though the world has been ringing with the doctrine of natural selection and the survival of the fittest for nearly half a century, no statesman ever dreams of taking these great principles into consideration when devising any scheme of education or social reform. On the contrary, it is a fundamental assumption in all our educational and social reforms that all men are born with equal capacities; that there is no difference in this respect between the average child of the laborer, sprung from many generations of laborers, and one born of many generations of middle- or upper-class progenitors; and it is held that all that is necessary to make the children of the working classes equal, if not superior, to the children of the bourgeois is the same food, the same clothing and the same educational advantages. On that account we have devised the so-called educational ladder. Yet if we ask any social reformer why are there middle classes, the answer will probably be that they are better off. But why are they better off? We are told that their fathers and mothers were better off, and that they thus got a better chance than the poor laborer. But why were the parents of these middle-class folks better off? Oh! they came of families that had been long well-to-do. But why were these families long well-to-do? At last we are brought to the conclusion of the northern farmer, that "Work mun 'a' gone to the gittin' whiniver munny was got," and to his brutal correlative respecting the laborers that "Them or thir feythers, tha sees, mun 'a' beän a laäzy lot."

Work no doubt has been a main factor in the evolution of the middle and upper classes, especially in later times, though undoubtedly other qualities, such as superior physique and superior courage, have been very important elements in the earlier stages. But at all times it is not improbable that the special quality which led to their rise was a superior self-restraint, that enabled them to resist the vices which are too often attendant on prosperity. This superior morale acts in turn upon the offspring by setting up a better standard of life in the home, which of itself gives children brought up in such an environment an advantage at the outset of life denied to the children of inferior parents. It needs no elaborate induction to prove that the middle classes are not the outcome of chance, but of a long process of natural selection and the survival of the fittest in the struggle for life, the two main factors in this evolution being, in the language of Aristotle, heredity and training. Each community is but a microcosm of the whole human race, which, as I have endeavored to show, is bound by the same laws as the rest of the animal kingdom. One race becomes a master because of its superior physique, courage, brain power and morale; another sinks in the struggle or lags behind owing to its inferiority in the very qualities which have given the mastery to its rival. What is true of master races in relation to inferior races is equally true of the individuals in each community. The middle and upper classes are in the main sprung from ancestors with better physique, courage and morale, and who have generation after generation been brought up in a better moral atmosphere than the children of the masses. Their ranks are also continually being reinforced by the best of the working classes. But this is not due to any educational ladder provided in modern times, for the process has always been at work, though of course its action has been distinctly aided by modern legislation. Medieval history supplies many examples of those who, though sprung from the humblest parents, rose to high place in church and state. This was not due to any legislative enactments, but rather to a principle well known in the whole field of nature. Every one knows that the superior varieties of flowers and vegetables are commonly the "sports," as they are termed, from inferior species. The skillful gardener watches carefully for good "sports," for they may become very valuable additions to his *répertoire* of useful plants. So, too, the legislator must watch carefully for good human "sports," not for those with criminal propensities. In the medieval world the church provided a ladder by which the son of the peasant could rise to be the counsellor of kings and princes. In modern times the state provides an educational ladder by which the child of the humblest parents may rise, if it has the capacity, to the highest positions in the community. It is right—nay, essential—that such a ladder should be provided, but this ladder is not for the mass of children. The vast majority can never climb beyond its lowest rung, owing to their heredity, and in a less degree to their home environment. The ladder is for the good "sports," who by its aid are thus continually reinforcing with fresh blood the ranks of the middle and upper classes.

It may be said that I underrate the number of the good "sports." Of course it is very difficult to get any exact statistics on so complex a subject; but according to information which I have obtained from one of our great industrial centers, where the educational ladder enables any child who passes the fourth standard in the primary schools before it is eleven to rise into the secondary schools, it is probable that no more than 5 or 6 per cent. of the children of the working classes have at the age of sixteen the same amount of brain power as the average children of the middle classes at the same age. But even all this 5 or 6 per cent. of "sports" can not be credited to parents of the working class alone, for it may be that a certain proportion of them must be ascribed to middle- or upper-class parents. Of course these rude statistics must be corrected by others collected on a large scale all over the country before we can form a final judgment; but I believe that the evidence already to hand makes it improbable that more than a very limited percentage of the children of the working classes have the same ability as the average child of the middle classes.

In ancient days the chief end of the legislator was to produce a stalwart brood of citizens capable of bearing arms in defense of their country and advancing her material prosperity. Still more ought this to be the aim of our legislators to-day, for under modern conditions great masses of population are huddled together in a manner hardly known to ancient cities. To accomplish this great end, the legislator must not merely look to improved housing of the poor and the development of the physique of city populations. He must, as far as possible, conform to the principles of the stock-breeder, whose object is to rear the finest horses, cattle or sheep. Amongst wild animals nature selects the fittest for continuing the race, and the wise breeder simply aids nature by selecting still more carefully the best animals. The legislator, on his part, ought similarly to foster the increase of the best element in the state, and on the other hand discourage the multiplication of the worst. Yet in our community statesmen of both parties have adopted the very opposite policy. The children of the working classes are educated at the cost of the state, the offspring of the wastrels are given free meals, and already there are demands that they shall be clothed at the expense of the ratepayers, and that the parents shall even be paid for providing them with lodging. It is not impossible that before long these demands will be conceded by either party in the state. The heavy additional expense incurred in this policy falls upon the middle-class ratepayers and taxpayers, who have to feed, educate and clothe their own children at their own expense. I may be said that they can get free education for their children by sending them to the state schools; but this is to level down instead of to level up; for if they do so they will be lowering the general morale of their own class, the most priceless asset of the nation. The heavy burden of taxation entailed by this policy, falling as it does with special weight on the middle classes, renders it more difficult each year for the young men and the young women in that class to marry before thirty, for they naturally shrink from the expense of bringing up large or even moderate-sized families. We need not, then, wonder at the falling off in the rate of increase of the middle classes. Our legislators are bad stockmasters, for they are selecting to continue the race the most unfit physically and morally, whilst they discourage more and more the increase of what we have proved to be the outcome of a long process of natural selection. The present policy, therefore, tends to reduce that which in all ages has been the mainstay of every state, the middle class. The yoemen of England, the free burghers of Germany and of Italy, formed the best element in the Middle Ages. So was it also with the great republics of the ancient world. Aristotle, in more than one passage, has pointed out that the middle class, that which stands between the "excessively wealthy" and the "very poor," between the "millionaire" and the "wastrel," are the mainstay of every state, and he shows that, where the middle class has been crushed out by the millionaire or the mob, ruin has inevitably overtaken the state. Indeed, it is clear that the chief defect in the Greek democracies was the smallness and weakness of the middle class, whilst it is notorious that Rome prospered only as long as the middle-class citizens flourished. Her downfall came when they were extinguished by the great capitalists, who made common cause with the masses against them. The latter had no patriotism, were incapable of bearing arms, and had no aspirations beyond free meals and popular entertainments at the expense of the state.

It is of great scientific interest to discover how the short-skulled peoples of Asia and Europe became differentiated from their long-skulled congeners; it is of great practical importance to apply to the administration of our great dependencies and colonies the lessons taught by anthropology; but it is infinitely more important to maintain a vigorous stock of citizens for the kingdom and the empire. Questions of the origin of races are, after all, only academic; but the other two, more especially the last, are intimately bound up with the life of the nation. If the present policy of our legislators is adhered to, the moral and the physical standard of the British citizen will steadily deteriorate, for the population will gradually come to consist of the posterity of those who are themselves sprung from many generations of the most unfit. Should this unfortunately come to pass, it will be the result of human pride refusing to apply to the human race the laws which inexorably regulate all nature.

CANADIAN WHEAT

By Professor JOHN WADDELL
SCHOOL OF MINING, KINGSTON, CANADA

FOR twenty years the Canadian government has been carrying on experiments in wheat growing under the supervision of the director of the Experimental Farm at Ottawa, Dr. William Saunders.

The United States leads the world in the production of wheat; Canada's growth is only one ninth as large, her export to Great Britain during the years 1901–3 was slightly less than one fifth, though in 1905 it was somewhat more than one half. The year 1905 was very abnormal, however. The United States export to Britain was exceedingly low and was surpassed by those of Russia, Argentina and India. But Canada's growth of wheat, though much less, is greater in proportion to her population, and in view of the many millions to be fed in the United States, it seems natural that before long Canada will export a greater quantity than she. Considering the circumstances, this is as natural as that America's output of coal and trade in iron should be the greatest in the world.

But the greater part of the Canadian wheat area is north of the forty-ninth parallel of latitude and so Dr. Saunders has experimented in growing wheat as far north as possible. The climate in America is colder than at the corresponding latitude in Europe, and so far, at least, we have no records of wheat being grown in Canada as far north as in Russia, but a near approach has been made. Winnipeg's latitude is 50°, and wheat has been grown at Dunvegan on the Peace River, on a parallel of latitude 414 miles north of Winnipeg; at Fort Vermillion, farther down the Peace River, 591 miles by latitude north of Winnipeg, and at Fort Simpson on the Mackenzie, 818 miles north. The latitude of Fort Simpson is approximately sixty-two degrees or within five degrees of the Arctic circle. The length of the summer days compensates for a lower temperature, and the time of ripening of some of the earlier grains is practically the same as in Ottawa. At Fort Simpson 107 days were required as compared with 106 days in Ottawa, some sixteen degrees farther south. Sixteen degrees south of Ottawa is New Orleans. Among the first experiments were comparisons of different varieties of wheat and these experiments are still carried on continually. Some varieties, probably by far the greater number, are cultivated for a season or two only, because they prove to be worthless, but many are sown year after year. These experiments are carried on not only at the central station at Ottawa, but at other stations as well, chiefly in the northwest. Plots one fortieth of an acre in size are found most convenient for the preliminary tests. When varieties are tested for productiveness the condition of ground and cultivation and seeding are made uniform and it has been found that productiveness is in a large degree persistent. Thirty-one varieties of wheat were grown year after year for five years, and of these a select list of the best twelve was made each year. It was found that there were only sixteen varieties that entered this list during the five years, the varieties that were superior in one year being for the most part superior always. Productiveness is, of course, an important consideration, for, other things being equal, an additional bushel per acre means an annual increase of four million dollars with Canada's present wheat acreage, and a correspondingly larger increase as more land is brought under cultivation.

Red Fife is the standard variety of wheat in Canada. It was imported in 1842 by Mr. David Fife, of Otonabee, Ontario, and was part of a cargo brought from Danzig on the Baltic, to Glasgow, and there transshipped to Canada. Dr. Saunders found that during the nearly fifty years that Red Fife had been cultivated there had been no deterioration, the quantity and quality of crop were as good as ever and in the northwest appeared even to improve. But it is rather later in ripening than is desirable where frosts set in early, and one of the great objects aimed at has been to cultivate a variety having the good qualities of Red Fife and at the same time maturing earlier. If also increased productiveness, quality of grain, strength of straw, or ability to resist rust could be attained, so much the better. The value of early ripening is evident when one realizes that two or three weeks' gain in this respect enables a variety to be grown several hundred miles farther north.

One of Dr. Saunders's first measures was to import varieties from all parts of the world where wheat was grown and to test their development under the new conditions. The United States, Japan, Australia, Russia, and even India, contributed many varieties. It was fortunate that the collection was so world wide, for the unexpected happened. It was found that several varieties from India were among the earliest. This proved to be because they were grown in the Himalayas. Thereupon special attention was paid to India, and at a height of 11,000 feet a variety was obtained, the Gehun, that has since been the subject of much experiment. This, along with the Ladoga variety, obtained from the district surrounding the lake of that name, and the Onega variety, from near Archangel, has proved the most promising of the early wheats imported and thus an altitude of eleven thousand feet in a latitude of twenty-five or thirty degrees offsets a northern latitude of sixty or sixty-five degrees at a low level.

New varieties have been obtained by selection and cultivation of natural variations, but a new era was begun on July 19, 1888, when the first experiments were undertaken in the cross-breeding of wheat on the Experimental Farm, and since that time several hundred new sorts have been produced and tested. None of the imported varieties which mature earlier than Red Fife were found to equal it in quality, and in originating the new productions by cross-fertilization Red Fife has in the majority of cases been one of the parents. Ladoga is about a week earlier than Red Fife and is fairly productive, and numerous crosses were made between the two. The most promising of the offspring were carefully cultivated and subjected to rigid inspection, all less desirable sorts being promptly discarded, and the better ones multiplied till seed was obtained for large plots. Of the progeny from this cross, perhaps the most satisfactory and promising are the Preston, a bearded variety, and the Stanley, beardless. These varieties are twin. They originated from one kernel. The heads produced the first season from this kernel were all bearded, but when the seeds from these heads were sown the year following, some plants produced bearded heads and some beardless, and afterwards each variation was cultivated until the type became fixed. The Stanley is from four to six days earlier than Red Fife, is equal to it in milling structure, appearance and strength, but a nine years' comparison shows that on the average it is less productive, its yield being 32 bushels, 2 pounds, against 33 bushels, 7 pounds, in the case of Red Fife. The Preston is as early as the Stanley, is more productive than Red Fife, but is of a slightly lower grade, worth in the London Corn Exchange about three quarters of a cent per bushel less. The value per acre is higher than in the case of Stanley or Red Fife.

Ladoga has also been crossed with White Fife, a variety slightly more productive than Red Fife. The most valuable of the progeny are Huron, which is bearded, is early and is slightly more productive than Red Fife; and Percy, also early, equal to Red Fife in quality, but even less productive than Stanley, yielding as a nine years' average about one hundred pounds less wheat per acre than the standard Red Fife.

Neither Gehun nor Onega is very productive, but, as before stated, they are both early and of their progeny Early Riga ripens eight or nine days earlier than Red Fife. Its productiveness is more than two bushels per acre lower than Red Fife, but its content of gluten—the most important constituent of wheat—is higher. I quote Dr. Saunders's words:

The reports on the Early Riga wheat are most gratifying. The proportion of gluten found in this variety is about twenty per cent. more than in Red Fife and the quality of gluten equal. To find a wheat superior in quality to Red Fife is what one would scarcely expect; but to find that superiority associated with so much earliness—from eight to nine days as an average of five years' trial—is highly satisfactory. The general introduction of such a wheat will probably extend the wheat-growing area in Canada and make it successful at points farther north than is possible with the varieties at present grown. The fact that it falls a little below Red Fife in yield is more than atoned for by its earliness and quality. The outlook in this connection is most encouraging and the results a triumph of the skill of the plant breeder.

The relation between the very important varieties described may be represented as in the accompanying diagram:

Red Fife
33 bush., 7 lbs.

Ladoga
7 days earlier than Red Fife;
quality poorer.

Preston, bearded
4–6 days earlier than Red Fife,
34 bush., 41 lbs.
Strength and color marks
slightly lower.
Worth ¾ ct. less per bushel.

Stanley, beardless
4–6 days earlier than Red Fife,
32 bush., 2 lbs.
Equal in milling structure,
appearance and strength
to Red Fife.

White Fife
33 bush., 15 lbs.

Ladoga

Huron, bearded
4–5 days earlier than Red Fife,
33 bush., 11 lbs.

Percy, beardless
4–5 days earlier than Red Fife.
Equal in milling structure,
appearance and strength
to Red Fife.

Gehun
Early; not very productive.

Onega
Early; not very productive.

Early Riga
8–9 days earlier than Red Fife.
Gluten 20 per cent. higher, equal in quality and color;
dough slightly darker, reported "creamy white,"
instead of "white" as in the case of Red Fife.

The cultivation of the different varieties was carried on by Dr. Saunders and his assistants, but the value of the product was determined not only by the chemist of the experimental farms, but by one of the most competent authorities in England and by Mr. Julicher, of Minneapolis, one of America's best known wheat experts.

Though only a few varieties have been specifically mentioned in this article because they have been most thoroughly investigated, yet many others show great promise, some of them maturing two weeks earlier than Red Fife. These will probably prove valuable not only in northern latitudes, but also in cold and damp soils farther south. A variety that proves promising at one station is tested at the others and if it is satisfactory it is grown in plots larger than the experimental, and the very best grain is selected for further experiments.

Until within the last few years experiments on the milling properties and quality of flour of a new variety of wheat could not readily be carried out because small quantities of grain could not well be ground in ordinary flour mills, and several years were needed in order to grow a sufficient amount for testing, but now the use of a small experimental mill and of the necessary baking apparatus enables every new variety to be tested before it is distributed to farmers throughout the country. For experiments have not been confined to the Experimental Farms. After it has been found that a variety proves satisfactory on the small scale and in the special localities under the supervision of the government, the seed is sent out to all farmers applying for it. The first year 1,149 lots were sent out in this way; in 1906 over 45,000 samples, each of five pounds, carefully selected and done up in strong cotton bags. In order to provide this seed, large areas are set apart, chiefly at the stations in the northwest, whence the grain is sent to Ottawa for distribution. The very earliest sorts are sent out so far only to those places where there is good reason to hope that they will be of particular value.

Dr. Saunders calculates that even without including the far northern territories the Canadian northwest could supply not only sufficient wheat for a local population of thirty millions, but have left over three times as much as the total import of the British Isles. This is on the assumption that one fourth of the arable land is devoted to wheat. If the northern lands are made available by the cultivation of very early varieties of wheat it follows that the possibilities of Canada are immense.

Dr. Saunders's work is therefore of the greatest value to Canada and must have an influence on the rest of the world as well.

COLLEGE STANDARDIZATION

By Professor W. LeCONTE STEVENS
WASHINGTON AND LEE UNIVERSITY

IN war between nations the standardization of armies is universally recognized to be the first essential of efficiency. The function of every leader, every fighter and every carrier is distinctly understood. Likewise in the domestic war of commerce, which is chronic, the organization of great corporations, with division of labor and singling of industrial functions, is the greatest promoter of both production and distribution. In theory the great corporation is a public blessing. In practise its beneficence has been somewhat concentrated, the benefit to the public being only incidental, but loudly proclaimed. The organized corporation receives from the state a charter, intended for the protection of the unorganized public. The corporation is justly held responsible to the state for the performance of the functions specified in its charter and for the avoidance of injustice to the public. The most troublesome problem of our country at present is connected with the enforcement of laws intended to protect the public from the greed of corporations, from false capitalization, from unjust discrimination in rates, from the corruption of legislation by indirect purchase of special privileges. Whether a tariff should be intended for national revenue or for protection to the special interests organized into great corporations is a question the settlement of which is already clear enough, but practically it may perhaps be reserved for a future generation. Whatever may be its settlement, the corporations are here to stay and no return to the simpler conditions of a half century ago can be expected. We are adapting ourselves to present conditions and in time this problem will be solved as others of no less magnitude have been solved by our fathers.

One of the real benefits to the public due to the existence of great corporations has been the development of a general demand for standardization. Everything must be measured that can be bought or sold. The results of work must be numerically compared; new units of measurement must be devised as soon as needed; secondary units must be derived from them; and familiarity with these must be readily attained by the public. Corporations must be compelled to give to the public a correct valuation of properties controlled, of profits earned, of wages paid, of business methods employed. Some corporations, such as national banks, have been for years already subjected to such regulation, with advantage both to themselves and to the public. The enforcement of the laws relating to banks has rarely ever been a hardship except to those that have made themselves unsafe by recklessness. Stockholders and depositors have a right to protection; and this might easily be denied them if the inspection of banks were denied. Such is human nature, that the temptation to dishmonesty is greatly reduced by the consciousness of responsibility and the knowledge that untruthfulness in accounts will be sure to bring its own natural punishment with little delay.

In the work of education the process of standardization is as inevitable as in other great industries, despite the fact that the training of the young is not directly merchantable and that industrial competition is not so conspicuous here as in transportation or manufactures. The American public-school system is an enormous educational industry, divided into as many state corporations as there are states in the union, and with as many subsidiary corporations as there are cities where municipal school systems are supported by local taxation. The growth of this aggregation of school industries since the close of the civil war has been proportioned to our national growth in population. The annual profits can not be expressed in dollars, but the value of the system as a popular investment is manifested by the willingness of the people to pay for the maintenance of such schools. During the twenty years from 1880 to 1900 the population of the United States grew from 50,000,000 to 75,000,000, and the enrolment in schools from 10,000,000 to 15,000,000; in each case an increase of 50 per cent. In the same interval the total estimated property of the country grew from $42,000,000,000 to $94,000,000,000, an increase of 119 per cent.; and the total expenditure for schools from $80,000,000 to $214,000,000, an increase of 162 per cent.

The rate of increase in expenditure for education was thus about one third greater than the rate of increase in wealth. The average expense to each person in the country for the maintenance of schools rose from $1.56 to $3.36. For salaries of teachers and superintendents the outlay rose from $56,000,000 to $137,000,000. A passing comparison may be here made with the amounts paid by the national government to the army of war pensioners; in 1880, $56,000,000; in 1900, $140,000,000. The function of a war pensioner is to teach patriotism, even if he has never been near a battle. His reward has much exceeded that of the teacher who has really earned his salary. There is need for a consistent system of standardization in comparing the value of the war pensioner with that of the teacher.

In most of our country the system of public education is well organized, and through the reports of superintendents every citizen can obtain all the information he wishes regarding school expenditures, courses of instruction, standards of scholarship, and general efficiency. Each state is supreme in the control of education within its own borders, and there is apparently little danger that public education will be made subject to the interstate commerce law and thus become subject to federal control. Although state organization is not equally thorough in all sections, the actual condition of public education in any selected state can be well ascertained by comparison of the reports required by law from all superintendents. Without the power of federal control the national bureau of education prepares and issues an annual report embodying a large mass of statistical information and discussion on education, most of which is gathered by voluntary contribution or by study of reports from all parts of the world.

When we pass from the domain of public education to that of private schools a change becomes perceptible. In the public schools there is well-defined gradation into primary, grammar and high schools, the high school generally including four years of well-adjusted work. In the private school there is no responsibility to the state, and each school fixes its own standards. There is more elasticity than in the public school, better opportunity for adaptation to individual needs, but less opportunity for an outsider to form a judgment of the pupil's attainments on presentation of a certificate of graduation. Much excellent work is done, but the opportunities for comparison between private schools are limited, and the opportunities for undue claims to excellence are great. These schools must continue so long as the need for unusual personal attention remains, or as parents are disposed to pay for the privilege of social exclusiveness. As they are usually not incorporated institutions, they can not be held responsible to the public for their standards, and are hence free from such inspection as is not specially invited. Some of them advertise largely, and pretentiously assume the name of colleges, institutes or military academies. In many parts of our country this is done apparently in obedience to popular demand, and is an index of the lack of local demand for standardization.

When we begin to consider the vast conglomerate of institutions that are incorporated as colleges, universities and technical schools we enter a region of chaos. If a school applies to a state legislature for a charter of incorporation as a college there is at present no standard generally recognized by legislators to determine what is a college. To most of them it means merely a school controlled by trustees who form a corporate body, and whose liberty must not be limited so long as they obey the existing laws of the state. It is greatly the exception to find in any state a law intended to protect the public from fraudulent colleges. Such a law was passed by New York a dozen or more years ago. Its main features are as follows:

For an institution to be chartered as a college, (1) it must have at least six professors giving their entire time to college work. (2) It must require for admission not less than four years of high-school work in addition to the preceding full work of the grammar school. (3) It must give a course of four full years before granting its degree. (4) It must have a productive endowment of at least $200,000. This of course excludes the valuation of land, buildings, equipment, tuition fees or special benefactions.

If this law were adopted and enforced in every state of the union it would exclude five-sixths of the institutions now bearing the name of college or university. Whether such a standard is just or unjust is not for these institutions to determine. It depends partly on the standards of the preparatory high schools that are under the control of the state. No institution should be permitted to assume the name of college whose standard of admission is so low as to allow access for students who have not completed the full high-school course of four years. It depends also on the consensus of opinion among the majority of those who are doing college work in the different countries of the civilized world. The standard of admission just set forth is below that required by the universities in England and on the continent of Europe, and above that which has hitherto been possible of attainment in the southern parts of the United States, where the high-school course is often only three years in length. All standards are the results of agreement, either tacit or formulated, and the consensus of opinion among educators in the more densely populated parts of the United States seems to be that the New York law is not unreasonable.

Most institutions that assume the name of college claim that for the average student four years of college work are needed to obtain a degree. But obviously if the starting point is low the ending point must be correspondingly low, since the capacity of the average student is fairly constant. The claim may be made that examination standards are kept high in spite of low entrance requirements, so that only the best students can expect to be graduated, or even to get through safely in the year's work for a given subject. The present writer once entered a college class in mathematics that had sixty members at the opening of the session, of whom sixteen were taking the subject for the second time. At the close of the session he was so fortunate as to be one of only fifteen who were successfully passed. Of the sixteen who were second-year men seven had failed, and of the forty-four first-year men only six had been successful. The standard of attainment was reasonable enough, but the prerequisites for admission had not been so clearly expressed as to give an adequate idea of the ordeal to which the applicant was to be subjected. If three fourths of a class fail, this does not necessarily mean that so large a fraction of its membership is made up of students who have been unfaithful or of less than usual ability. The amount of teaching may have been insufficient, or the discipline too lax, or the student may have been admitted at his own peril when safeguards ought to have been provided to shield him from certain failure. No guarantee of success can ever be given; but, if he fails, his misfortune ought not to be due to the imposition of a standard that is possible for only the exceptional man unless the subject is one that implies exceptional scholarship. Unnecessary failure is a calamity, and a fairly good student has the right to expect reasonable protection from it. Few institutions, however, venture upon such indiscriminate slaughter of the innocents as is implied in the case just cited. There may, of course, be exceptions, but in the majority of cases the real value of a diploma at the end of four years is quite fairly proportioned to the value of the entrance requirements at the beginning of that period.

The requirement of six professors giving their entire time to college work is one to which probably no exception can be taken by any who have real knowledge of the meaning of such work. A college to be successful must be well organized. Its head must be energetic, tactful, a good judge of men, thoroughly appreciative of high scholarship, a keen detector of efficiency in teaching, and the possessor of exceptional administrative power. Each professor must not only know his own subject, and how to teach it, but must be single-minded in his devotion to the interests of the institution. To devote most of his time, or even any considerable part of it, to the practise of a profession, with teaching thrown in as an incidental, is to ensure the sacrifice of the student's interests. Through the medium of the press he should keep in touch with the public, and especially with the educational and scientific world, but his main work is in connection with his students, and his income should be such as to make outside work unnecessary. So small a number as six of such men is scarcely sufficient to carry on the work of any modern college. If the New York law is objectionable the fault consists in prescribing a number that is too small rather than too large for a minimum.

The assignment of $200,000 as a lower limit for the productive endowment of a college is a very moderate recognition of what is implied in college teaching. With five per cent. as the rate of interest such a college would have but $10,000 as its income aside from students' fees. Assuming one hundred paying students at $100 each, the income is thus raised to $20,000. Of this, three fifths may be allowed for the cost of instruction, the rest being absorbed in the expenses of administration and operation. A salary allowance of but $2,000 is hence left for each of six professors, the president's salary being included in the cost of administration. The ratio of students to professors would be 100 to 6, or nearly 17, a number too large for the best efficiency. For reasons locally deemed satisfactory, many students are usually admitted without the payment of tuition, with no allowance to the professor for increasing his burden, so that the teaching ratio is raised from 17 to possibly 20 or more.

The Carnegie Foundation for the Advancement of Teaching published, in May, 1908, the teaching ratios of 93 leading American educational institutions, deduced from data furnished by them. For example, this ratio is given for Johns Hopkins as 4.3; Haverford College, 6.5; Harvard, 8.8; Tulane, 9.5; Texas, 14.5; Drake University (Iowa), 25.7. For the 93 institutions the general average is found to be 11.9. Disregarding other considerations, the possible efficiency increases as the teaching ratio decreases. Since each student ordinarily has several subjects of study and thus multiplies the number of persons taught at a given time by each professor, an average of 50 in each class is allowable, this number being often greatly increased for lecture work and diminished for advanced class work. Experience has thus shown that for good college work the average teaching ratio should not much exceed a dozen, though lecture audiences may be limited only by the capacity of the audience room.

There are seven or eight American universities having each an annual income in excess of $1,000,000. Of those which are still willing to retain the more modest name of college considerably more than a dozen have incomes in excess of $100,000, and endowments in excess of $1,000,000. Nevertheless the assignment of $200,000 as a minimum productive endowment would cause the forfeiture of many charters. In early manhood the writer's first teaching in an incorporated institution was in a "university" having a total endowment of $25,000. The connection was brief, and so was the life of the institution. The legislature that granted its charter was more obliging than well informed about educational standards.

A century ago such institutions as Harvard and Yale were almost without endowment and their annual budgets were nearly limited to the income from students' fees. But since the close of the civil war the growth of our country in wealth has produced unprecedented change in standards of all kinds. If the general standard of comfort in life rises with the prosperity of those in whose hands the greater part of the country's wealth is concentrated, the standard of college expenses may be expected to go up in like manner. Gifts have been showered upon institutions with favored surroundings and the ratio of total expenses to total attendance has been steadily rising. The college that has age, history and respectability without endowment is no longer sought by students who are prosperous enough to attend prosperous colleges, and its sad fate is not hard to predict.

With the growth of endowments and the enlarged scale of expenditure in all institutions of learning the student's tuition fee has been steadily becoming a smaller fraction of the cost of instruction given him. He generally pays less than half of what he costs. Every college student is now the beneficiary of organized charity, and the self-sustaining college is a thing of the past. The larger the number of students the more unprofitable is the work pecuniarily, unless the growth in attendance is accompanied by corresponding increase of endowment to balance the excess of total annual cost over receipts from tuition fees. In ordinary business the condition is reversed; the larger the scale the greater are the profits possible.

From the popular business standpoint the success of a college is more readily measured by its number of students than by the quality of its work. So urgent is the demand for numbers that it is not uncommon to see the need for increased equipment disregarded, the library prevented from growing and remaining stuffed with out-of-date rubbish; and the professors overworked. As soon as the teaching ratio exceeds a dozen the need for increasing the teaching force becomes imperative. This can not be done if the endowment is too small to permit the payment of living salaries to competent assistant professors. The most ready resource is to impose the duty of teaching upon inexperienced young holders of scholarships, or to grant the remission of tuition fees to selected undergraduates on condition that they perform the function of assistants in the laboratory, the library, or the office of the language professor. If the efficiency of these undergraduate assistants were proportionate to their pecuniary needs, or to their willingness to do their best, such procedure might have some justification. These undergraduate names are recorded, both in the register of students and in the faculty list, and on dividing the number of students by this nominally enlarged faculty number the alleged teaching ratio is brought down so as to present the appearance of efficiency. The public is misled and the college made to appear stronger than is warranted by the facts.

If objection is urged against what has just been set forth, the ready reply is that the only way to impress the public and to attract benefactions is to grow rapidly and let the public know it. The resort to cheap labor in employing inexperienced undergraduates for assistants, and including them in calculating the published teaching ratio, is to be regretted; but it is locally deemed a less serious evil than any check in the rate of growth, even if the endowment fund remains stationary. It is urged that this course is necessitated by the sharpness of competition for students; that catalogue statements must be interpreted liberally, because competitors disregard their printed entrance requirements; that many preparatory schools do not give four years of high-school work, and hence the colleges must adapt themselves to this condition. Some school principals reply that they are anxious to give the fourth year of work, but can not retain their pupils because the colleges admit these as special students; and articulation between school and college, though most desirable, is thus impossible. The inevitable result is loss of confidence, on the part of these schools, in the disposition of college authorities to deal justly or consistently with them. Rapid growth is indeed desirable, but growth of the faculty is quite as important as growth of the student body. If faculty growth is impossible then the standard of admission should be raised, and the severity of examinations increased, until the student body is cut down to such dimensions that an equitable teaching ratio is recovered. This necessity is fundamental. A reputation for thoroughness, for strict accordance between profession and practise, is better than large numbers. The faculty should be limited to trained specialists, and the students naturally expect instruction from teachers of more maturity than can be expected from those who are members of the student body.

There can be no reasonable objection to the employment of student-assistants if their responsibility is limited enough and no use of their names is made by including these in the published list of apparently responsible instructors. To quote from the second annual report of the Carnegie Foundation (p. 18):

> The instructing staff includes every person giving regular instruction in the institution except undergraduate assistants. These latter manifestly should not be counted in the teaching force even when they give some teaching. They are primarily college students.

For colleges whose feeding schools are largely compelled to limit themselves to three years of high-school work an abrupt change to the standard of the New York law is very difficult, if not impossible. If honestly carried out, the change necessitates great loss in numbers. The natural resource for aid is to secure a rise of standard in the local high school, which is in no way subordinate to the college and has no representation in its catalogue. A student coming with defective preparation may resort to this school until the full entrance requirements are fulfilled. Many applicants would undoubtedly be lost to the college on account of unwillingness to continue in the high school, but this is the price that has to be paid for standardization. Within a few years there will be improvement for the college, in both numbers and quality, due to the advance of standard. In Virginia the improvement in high schools during the last ten years has been very marked, and their reactive effect on the colleges is distinctly recognizable.

Among the most insidious of the evils in colleges that strive for numbers is the indiscriminate admission of special students, and of students on certificate from so-called accredited high schools which are not subjected to inspection. The theory of accrediting is that the school gives its certificate of graduation only to students who have successfully completed the full period of four years, with final examinations quite equal to the entrance examinations of the best colleges. The student takes examination on all his subjects immediately after studying them, under conditions to which he is accustomed, and not under the harassing stress of a college entrance test. The work of the college examining board is thus greatly reduced, and the responsibility for the student's possible failure is borne by those who have taught him and have deliberately vouched for him. The school is included in a special published list only after careful inspection by the college authorities or by a state official. If its pupils fail to maintain themselves creditably after admission to college the school is dropped from the accredited list, with danger to the principal, who may be displaced on the ground of incompetence if he is the head of a public school. Such displacement has been produced more than once in the northwest. If these conditions are fulfilled there is little ground for complaint, except that the applicant for admission does not take a general review of all his work before entering college, and hence he has forgotten much of what was once studied. On this account the formal entrance examination is estimated to require about a year more of work than entrance by certificate.

But in some parts of our country, notably the southern and southwestern states, inspection of accredited schools is almost unknown. For one college probably an accredited school is merely a school that can furnish students, and admission by certificate serves the convenient purpose of removing responsibility from the college authorities without fixing it anywhere. The president knows his own interests, and avoids expressing adverse criticism if a student admitted is found badly prepared, because the principal may be offended and may advise his pupils to go to another college. The principal of M. Academy finds young *A*, who is a good athlete, determined to quit school and get into some college team. He knows that a certain college is urgently in need of athletes and not exacting about entrance requirements. He gives to *A* a certificate which is accepted on sight, and no questions are asked. The football season is better than usual, but *A* fails in the first examination season and drops out. Nobody is held blameworthy, and M. Academy is encouraged to send more athletes whenever these can be secured. It is not deemed important that four years of solid preparation should be insisted upon, but this would be very acceptable if an entering athlete comes with such an unusual qualification. Even if he has no perceptible preparation he may be admitted as a special student, whose name helps to swell the registry list. One such is known to have entered at the beginning of the baseball season, going off with the team on the day after registration. On his return, when asked what were his subjects of study, the sober reply was, "Latin, economics and academics." Neither the professor of Latin nor of economics ever formed his acquaintance, and the professor of academics could not be found. But all entrance requirements had been fulfilled for admission to spherics, if this name be applied to ball play. The obvious moral is that no special student should be allowed membership in an athletic team. The mere fact of such membership is presumptive evidence that he is a special fraud.

The criticisms expressed in the present discussion are the outcome of observation, conversation and correspondence extended through a number of years. They are applicable, at least in part, to a variety of institutions, no one of which is here singled out as a special object of attack, either directly or by implication. The facts are well known to many who are engaged in the work of college education, and there is no wish here to individualize. One of the worst causes of their existence has been the all-pervading pressure of intercollegiate athletics. An institution with few professors and many students, which has much ambition for athletic reputation and therefore has admitted athletes with little discrimination, is confronted with an embarrassing choice of alternatives. It is well established that the average scholarship of athletic teams is low. Those who openly contend that a high standard of scholarship is preferable to a high standard of athletics are exposed to the danger of unpopularity among students, and perhaps among others. Unwelcome criticism based on known facts may be deemed inconsiderate or in bad taste, but evils are rarely ever rectified by ignoring them.

About a thousand American institutions of learning are said to have been chartered as colleges, universities and technical schools, or at least permitted to call themselves by such names. There is no hope that fraud will cease to be practised among them, for every one of them is an index of local civilization, and legislatures are generally willing to incorporate colleges whose standards suit their constituencies. But a hopeful road to improvement is found if every legislature can be induced to follow the example of New York, settling by statute the conditions to be fulfilled for the issuance of a charter of incorporation. Every such charter should be granted for a limited period, such as ten years, and all charters should be revoked if the institutions holding them are unable to meet the requirements of the law. The strong institutions would not be affected, and would have no difficulty in securing decennial renewals. Charters now in existence can not legally be affected, but no new applications for charters would be made with the plea that these are intended to meet future expectations rather than present conditions. It is not to be expected that the law for Virginia or California would be the same as for New York or Florida; but the valuable gain would be the establishment of a definite standard in every state of the union, while the usual condition now is that of no standard whatever. The crying evil is false pretense, the assumption of misleading names, the claim to excellences that do not exist.

In contrast with the New York standard may be mentioned a certain "university" in Florida. Its catalogue in 1903 presented a faculty list of 69. Of the 450 students 6 were in the kindergarten course, 35 in the primary department, 141 in the school of music, 58 in the college of liberal arts—doubtless very liberal—and 210 scattered through other departments of less importance. This fortunate university "received its charter from the Legislature of the State of Florida." Of its faculty "the majority have pursued graduate courses in American or European Universities" and are "Christian men and women"; hence it would be uncharitable to think that good work is not done. In the mathematical courses the work offered includes "osculation, roulettes, Jacobians, gamma functions, various volutions of cubics and quartics, homographic division, reciprocal polars, conic invariants, and covariants."

The national pure food law has lately mitigated the evils of false pretense in the sale of food and drugs. We are in need of similar protection against those who secure charters for universities with kindergarten departments. The chief function of these universities is to nullify the meaning of college degrees.

In the second annual report of the Carnegie Foundation the president, Dr. Pritchett, says (p. 37):

> Some thoroughgoing financial statement of investments, annual receipts and expenditures should be required by law of all chartered institutions. There is the same reason for a college to exhibit in a business-like way its financial history as for any business concern; and every institution should do this as a matter of good faith.

Probably the mere possession of a charter from the state might be considered sufficient reason for the annual rendition of such a report to the state superintendent of education. He would naturally publish a comparative summary for the different institutions thus represented. For the larger institutions the treasurer's report is always printed and is subject to inspection by those who may be specially interested in it. The financial statement is summarized by each treasurer according to his own plan. Probably it might be best for a common plan to be used by all institutions in the same state. Of late years there has been so much criticism of "bought patronage" that it would be wise for each institution to publish the total amount remitted from students' fees without mentioning the name of any beneficiary. The impersonality of such a statement removes all reasonable objection to such publication.

In addition to its financial statement it would perhaps be very desirable that every college should be subject to examination in such matters as the maintenance of its professed standards of admission and graduation. No detailed investigation of this kind would be possible without treading on delicate ground. It has been suggested that this function might be delegated to a state commission; but the intrusion of politics would be a serious danger, probably nullifying the benefits sought, even if the facts were attainable. In such matters there is probably no resource but the assurance that the reputation of the institution is obliged in time to suffer if its dealings with the public are not what the public wants. If a high standard of admission is professed and violated, students are quick to detect the fact and to circulate their impressions; and no prying is needed to learn what is generally thought to be the truth. They are the most wide awake and relentless critics that the college can have, and they are more efficient than catalogues, bulletins or commissions in determining the public estimate of its character.

No national law for the protection of genuine educational institutions can be secured, because the control of education is not among the political powers delegated to congress by the constitution of the United States. The case in America is quite different from that in Germany, where professors are commissioned by the imperial minister of education. But within the last few years a national agency of great importance has been brought into existence by the organization of the Carnegie Foundation. The Carnegie board has adopted the New York law as an initial aid in classifying the American educational institutions that seek to secure the benefits of the foundation. The granting of retiring pensions to those who have grown old in the work of college teaching is an uplift that benefits the general cause of education quite as much as the individual beneficiaries of the fund. The annual reports and bulletins of this board have been among the most important contributions to educational progress that have ever been published in this country. In a study of the financial status of the professor in America and in Germany the data were secured by which an illuminating comparison is made between about 160 of our leading educational institutions, including at least two thirds of all those to which the name of college, university or technical school is properly applicable. Although the first wish of the donor was that the fund should be limited to institutions that are not under the legal control of church or state, this limitation has been interpreted with the utmost liberality. The fund has been enlarged to include state institutions of high standard. A college, originally sectarian, may retain with its denomination a relation of "traditional friendship and sympathy, but not one of control." About sixty institutions are already on the accepted list, and others are striving to throw aside denominational shackles or to improve up to the standardized requirements. To attain an end by causing competitors to strive for a prize is better than to make them obey what they may deem a repressive law, even if the law is judicious. The Carnegie Foundation is quietly preparing all the states of the union for improvement in their laws about the chartering of colleges, and it is to-day the most effective agency that tends toward college standardization.

ASPECTS OF MODERN BIOLOGY[1]

By Professor T. D. A. COCKERELL
UNIVERSITY OF COLORADO

DURING the latter part of August, last year, the International Zoological Congress met at Boston. This circumstance was not very widely heralded by the press, nor did it make an impression on the public mind at all comparable to that ordinarily produced by any serious crime. Nevertheless, it was an event of the first importance, this gathering of the zoological forces of all civilized countries to take stock of the progress of the science and exchange fraternal greetings.

To present any summary of the things said and done at that meeting is neither desirable nor possible at the present time; but it may be useful to consider what it all meant—where zoology now stands, and what it stands for.

Most typical, perhaps, of the whole trend of zoological thought was the address of Professor William Bateson, of Cambridge University. It dealt with the subject of genetics; the genesis of things, cells, individuals, species. It told of sequences actually observed rather than contemporaneous facts arranged in rows. The methods advocated were experimental, the range of investigation was the whole field of life.

At the same time, the geneticologist did not refuse to recognize the value of the other methods of research. Said Professor Bateson: "When morphology was a new idea, everything was sacrificed to its pursuit. Physiology, systematics, all were discarded as useless lumber. Let us not repeat that short-sighted mistake. In the wider survey which we are attempting we shall need all these things. If we are to understand rightly the phenomena of specific difference—to take that problem only—we shall be glad of anything that the systematist can tell us, and of many deductions of pure physiology."

The old natural history is having a new birth, with new hopes and aspirations, but with the same unity of interest and of purpose. With the growth of science, specialization was necessary and desirable. Yet as time went on and zoology not only grew apart from botany, but the various branches of zoology seemed to have different languages, it appeared as if a tower of Babel would result. Even the systems of nomenclature for genera and species, ostensibly the same throughout, came to differ appreciably in different departments; and the various

[1] Lecture delivered before the Scientific Society of the University of Colorado, January 20, 1908.

specialists were so segregated that they were scarcely or not aware of the fact. The grouping was sometimes according to classes, orders and families; sometimes according to physiological or morphological aspects of things; but everywhere it seemed that narrowness increased, and that broad conceptions of the Darwinian type were fading away.

The new attitude typified by Professor Bateson not only unifies the branches of zoology, but makes zoology and botany one. Greedy for the results of special research in every department, it yet makes all serve a common end. So far from despising or discouraging the most minute enquiries in limited fields, it gives them all a new purpose and new meaning, as contributory to the philosophy of life, which is, indeed, the sum of all philosophy. We find ourselves at that meeting point of monism and dualism, of synthesis and analysis, where the electric spark of human understanding always has had and always will have its birth.

Professor Forel, of Switzerland, in a recently issued book, has called attention to the difference between mathematical and ordinary reasoning, including in the latter the methods necessarily employed in the biological sciences. In mathematics, we start with certain postulated facts, and given definite methods of procedure, climb up a ladder of argument, each part of which is supported by the one below. An error at any point vitiates the whole piece of work; while, if there is no error, the result is said to be demonstrated beyond dispute. Systems of logic have been constructed in the same manner, and such processes have found great favor with lawyers and theologians whose main purpose has been to support theories rather than ascertain the truth.

In the natural sciences, as in the every-day affairs of life, the method is entirely different. Desiring to determine the state of things at any point in time or space, we converge upon it all the pertinent evidence we can secure, and form a judgment upon the collection. We do not profess to exclude the possibility of error; rarely do we feel so well supplied with facts that others are not welcome. Those of us who have worked long among biological facts have so often made mistakes, or discovered the mistakes of others, that we have become somewhat more humble-minded and less assertive than we used to be. This humility, however, is coupled with a keen sense of the tremendous weight of evidence in favor of certain conclusions. We do not assert that we *must* be right, but we at least demand an equivalent load on the other side of the scales before changing our opinion: a demand not readily comprehended by those to whom our body of facts is invisible.

In Colorado to-day we find existing many millions of individuals of animals and plants, presenting extreme diversities of form, color and size, and distributed in certain particular ways. It is the business of the naturalist to find out the how and why of all this, so far as he can.

Before he attempts to formulate general laws, he must collect his facts, and examine them in detail. He goes out, perhaps, and gathers a flower: let us say the blue flax, *Linum lewisii.* The very name tells him something of its history; it was called *lewisii* in honor of Meriwether Lewis, of the famous Lewis and Clark expedition. It has been known since 1814, and has been collected by many botanists. Turning to the published records, it appears that it has been found as far south as the mountains of Mexico; as far north as Alaska. It does not occur in the eastern part of the continent, north or south. Among the native plants of America it has only one close ally, a smaller plant called *Linum pratense*—we may call it the prairie flax—which occupies open ground east of the Rocky Mountains from British America to Texas and again appears in Arizona.

In Europe and Siberia, however, there are closely similar plants; so like our *Linum lewisii* that for many years our plant was not separated. Furthermore, there are various other species of *Linum* or flax in the Old World, some of them strikingly different from ours. These, some with blue, some with red flowers, are more closely related to one another than to the yellow-flowered flaxes, which have lately been placed in a separate genus.

From all these facts, it is permissible to assume (in the absence of contrary evidence) that the genus *Linum,* in the restricted sense, belongs especially to and probably originated in the temperate regions of the Old World. This opinion is fortified by the discovery of a species (*Linum oligocenicum* Conw.) in European amber of Tertiary age. We imagine, then, the true flaxes originating perhaps in central Europe or Asia, segregating into various distinct species, and finally, perhaps during the Miocene period, invading North America. From the present distribution of the plant, we should naturally infer that it came by way of Bering Strait, not across the Atlantic; and from its slight divergence from the Old World stock we should think of it as a comparatively recent immigrant. The prairie flax, occupying a lesser area, and not so similar to the Old World type, is regarded as an offshoot from Lewis's flax, adapted to life on the prairies, the former occupying the mountains.

Leaving the flax for the moment, our naturalist hunts about and picks up a small shining cylindrical shell known as *Cochlicopa lubrica.* This snail is distributed widely over the continent, from Canada to Alabama, and west to the Pacific coast region. It is very constant in its characters, but in a few states has given rise to a variety or closely allied form of larger size called *morseana.* There are no other American allies.

So far, there is no apparent clue to its history; but when we turn to the eastern hemisphere we find a very different state of affairs. In the regions surrounding the Mediterranean there are dozens of species of shells of the same general type, while *C. lubrica* itself is widely spread over the whole of Europe. Moreover, this species *lubrica,* so constant with us, is there much more variable, so that nine varieties have been found in the British Islands alone.

The presumption is, then, that the snail, like the flax, is of Old World origin, and represents a comparatively recent invasion from the ancient area of distribution. This is supported by the occurrence of allied but distinct genera in Europe and adjacent regions.

Further investigation reveals hundreds of other cases similar to those of the snail and the flax, and so it becomes more and more probable, finally practically certain, that we owe a considerable part of our fauna and flora to the immigration of animals and plants which has reached nearly their present condition on the other side of the world. We ourselves, of course, belong in this category.

Having arrived at this point of view, the subject must not be dropped, but should be attacked from another side. If America has been overrun by Old World types in comparatively recent times, it should be possible to get some idea of the time of these invasions by examining the fossils of various strata. Unfortunately, the paleontological record is very imperfect, but it yet yields facts of prime importance. We find that certain types, living in Colorado to-day, have lived here with only slight modifications for many thousands, perhaps some millions, of years. Others are totally absent, so far as our information goes, from the older Tertiary strata, but negative evidence of this kind must always be received with reservations. Others, to-day only found in Asia, Africa, Europe or South America, were conspicuous members of the Colorado biota. Here we find facts which throw doubt on some of our previous conclusions. The Equidæ, or horse family, have to-day numerous members in Africa and some in Asia, but none whatever in America. Yet we have evidence from the fossils that there were formerly horses in America, and that they actually evolved on this continent. The disease-carrying tsetse flies are to-day exclusively African and might well be thought a peculiar product of that continent, but a species has turned up in the Colorado Miocene! So with other cases, all tending to show that it is not safe to assume without question that the original center of a group is the region where it is now most abundant and varied. We do not thereupon decide that the evidence from present distribution is valueless; in many more instances it leads to exactly the same conclusions as might be derived from the fossils; but we recognize the importance of supplementing one kind of fact with another, and considering all together when forming conclusions. When using the paleontological evidence, we are struck by the differences between the fossils of successive strata and are always inclined to regard these as indicating widely different periods. Here the facts of present distribution serve to make us hesitate. Different altitudes, different soils, different conditions of moisture and so forth, produce to-day very distinct sets of animals and plants, even in the same immediate region. Or, if we are dealing with marine forms, a littoral and a deep-sea fauna of precisely the same age would be very different; indeed it is doubtless not an exaggeration to say that the present shallow-water fauna of the Atlantic coast resembles the shallow-water fauna of Middle Tertiary times much more than the deep-sea fauna of to-day. Considerations of this sort have led careful paleontologists to attempt to estimate the climatic and other conditions surrounding the subjects of their investigations; thus, for instance, Dr. Matthew, in discussing the Tertiary mammals of northeastern Colorado, concludes that one series represents a plains or prairie fauna, the other a forest one. These are not of the same age, but the difference between them is clearly to be attributed to environmental conditions as well as the lapse of time.

Thus in the course of our enquiry we come back to the modern biota, and find it necessary to ascertain as accurately as possible what conditions permit the existence and migration of the several species. Neither the blue flax nor the snail exists everywhere within the region which we said, in general terms, that they occupied. The flax occurs at various altitudes, up to 10,000 feet, but always in more or less open places, in dry or at least not very moist soil. The snail also lives at different altitudes, but in moist places under vegetation. Thus, although when plotted on a map the ranges of the two would appear to largely coincide, it is probable that they never, or almost never, actually exist together. While spreading over enormous areas, they have picked their way, as it were, from one suitable spot to another, showing thereby how closely they are dependent upon a particular set of conditions. In a general way, mountains may be said to favor the spread of both, and for either the desert is an impassable barrier.

When we have ascertained the necessary conditions of moisture, heat, light, etc., we have not nearly solved the problem. Very important, in nearly every case, is the living environment. In the case of the flax, we know that it is very injuriously affected by an orange rust (*Uredo lini* (Pers.) Schum.), which extends practically throughout its range. This rust infests not only the blue flax, but other species as well, including some of the yellow ones. Consequently, when two geographical groups of flax plants meet, whether they are of the same species or diverse, there is always a possibility that one will convey the rust to the other, supposing that they are not both already infested. The same sort of thing is true of diseases of animals, as many races of men have found to their destruction, upon mingling with the white man. The competition between allied species is thus often indirect, one destroying another by conveying to it some disease.

The flax is visited by various bees, which I have studied and recorded; these carry the pollen from flower to flower, and thus aid in pollination. Whether the necessary bees are always present, is not yet known; but their presence in numbers must be a favorable factor, and thus an important element in the living environment.

In the case of the snail, although it is so common, we know little or nothing about its natural enemies.

The more we study living creatures the more we become impressed by the complicated conditions necessary for the preservation of the higher forms, and the possibilities of local or complete extermination. As we determine these more accurately, we feel able to return to the fossils, and from them restore the past in much more detail than at first seemed possible. If a snail or a slug crossed from Asia to America we presume that it not only found continuous, or nearly continuous, land, but also that it did not traverse any desert. The path of migration of the blue flax was not, it is virtually certain, across a lowland region or swamp. Making all allowances for what are called accidental means of transportation, it ought to be possible to infer something about the pathway of a considerable number of species.

In all of these researches, success and failure are inextricably mixed, at least as regards the details. In no case can we gather all the pertinent facts; our knowledge of even the commonest species is very deficient. Yet, when all is taken together, we find ourselves like the man who said he lost on every job, but was able to make money because of the multitude of them. The number of known species, living and extinct, is enormous, and the data we have gathered, when suitably sorted and arrayed, will point to many definite conclusions. More especially is there reason to hope for good results to be derived from studies which past investigations have merely suggested and shown to be possible.

As a matter of history, as food for the imagination, it is interesting enough to watch and take part in the reconstruction of the past, especially when we are able to do this with a reasonable degree of completeness, as at Florissant in Colorado, or Œningen in Germany. Much more, however, may come of these investigations. The problems of evolution, the intricate questions of heredity and variation, may be answered in part by such means as I have described.

The experimentalists, represented by Bateson, De Vries, Tower, MacDougal, Davenport and many others, have ascertained that what appear to be new species or races may arise suddenly by a process termed mutation. It even appears that in certain cases this process may be brought about by artificial means, such as differences of humidity, or certain substances in solution, supplied at the proper moments. The obvious suggestion is, that species are more readily modified than is commonly admitted: and that in particular they are likely to be so modified on the borders of the territory they occupy, where they continually impinge on unaccustomed environments.

To show that this is possible is a most important step; but we still have to enquire how far has it actually occurred? In the case of our flax, we have an excellent example of the production of a new form on the periphery of the old, permitting expansion through modification; but only one such derivative seems to have been produced. In other instances, as the experimentalists have shown, the apparent instances are illusory, the supposed geographical segregates being merely examples of a single type variously modified by the direct action of the environment. The most striking evidence of this sort has been furnished by Beebe, who has produced in certain birds, by means of humidity, more difference that has been accepted as sufficient for the distinction of subspecies. Leaving out all such phenomena, we still have a great series of closely allied species, with undoubtedly inherited characters, presenting the same kinds of differences as have been observed to arise by mutation, sometimes apparently as the direct result of particular stimuli. What do these phenomena mean in the practical working out of evolutionary processes?

If we know in a general way the age of particular types and the extent of their migrations, we can begin to form an idea of their practical mutability. The vertebrate paleontologist finds evidence of remarkable changes within the Tertiary period, but even he has to admit that the course of evolution is not so rapid as it might seem; that new forms suddenly appearing must surely have migrated from other regions, where they doubtless underwent a slow process of development. Central Asia, we must now think, must have been the home of various groups, and will one day yield fossils of surpassing interest. Africa, once seeming so barren paleontologically, has of late begun to yield her treasures.

The student of fossil invertebrates finds the process of change to have been, in the majority of cases, extraordinarily slow; and the paleobotanist finds it slower still. It is not that plenty of specific forms were not produced, but the generic and higher types were so little susceptible to change. A wrong impression has been produced, even among the vertebrates, by the presence in different strata of remarkable extinct groups. No doubt two or three species of elephants walking about in our mountain-parks would give a strikingly different appearance to the Colorado landscape; but the time since this actually occurred is, geologically speaking, very inconsiderable, and does not represent any great step in the process of evolution. The more I study the insects and plants of the Florissant Miocene, the more convinced I become that, speaking broadly, the extinct genera and higher groups are not the ancestors of any now living, but represent types which have failed, like the mammoth; while the real representatives of the modern biota show that there has been singularly little forward evolution in the course of perhaps a million years. Many of these are totally extinct in Colorado, but live elsewhere; thus the redwood differs little from that of California, while the wonderfully delicate and fragile *Halter,* belonging to a family no longer living in North America, is closely related to a living species of Persia.

Hence the experimental researches of De Vries and others, proving that mutation is a relatively common phenomenon among plants, prove perhaps too much. If change is so easy, why so little change, and that in the face of a radical change in temperature and moisture? It seems, indeed, that "elementary species" have always been produced in greater or less abundance, but by a sort of oscillation less related to the forward march of evolutionary activity than we might at first suppose. The ability to produce heritable segregates, especially in the face of adverse or strange conditions, is clearly of advantage, as giving new chances for spread or survival. Thus in the long run the tendency to break into "elementary species" would in many cases be favored by natural selection, without any necessity for each one of these, or even the majority, being directly related to a particular environment. There is no reason, apparently, why this should not continue for ages as an oscillation-process, a segregation in space rather than in time, producing thousands of species without overstepping the limits of the general group, or perhaps advancing at all in complexity. The molluscan genus *Ostrea,* the oysters, may be taken as an example of this; indeed, the modern oysters scarcely do justice to their Cretaceous ancestors. When it was generally held that species were created by divine fiat, it naturally appeared that he who should explain the origin of species might be given the rest without further charge. We are coming to see that there are diverse problems involved, and while the whole matter may well be locked up in the evolution of any single species, or indeed of any single cell, we begin to doubt whether we really possess the key.

Speaking philosophically, progressive or orthogenetic evolution—the existence of which no naturalist has any ground for doubting—must have a cause external to itself. All probability favors the idea that this did not operate once for all, but has continued in action throughout the ages. It may be found, perhaps, in the susceptibility of the hereditary mechanism to environmental influences of particular kinds, the nature of which remains for the present obscure. These reactions would fall under the operation of natural selection from the very beginning; thus a too susceptible organism would quickly be thrown out of gear and would perish; a too conservative one, unless adapted to practically unchanging types of life, would equally perish. There would be a certain optimum susceptibility, which would be preserved, and would differ for different groups. More than this, certain kinds of susceptibility would be favored, and being once developed might, like bad habits, become harmful through the accumulation of results, resulting in extinction. Thus rapid evolution would usually go with a high percentage of failures, and a considerable number of grotesque forms, such as we see among the vertebrates. According to this view, the initiation of any evolutionary trend, except the oscillatory movements above described, would be exceedingly slow, and quite beyond the reach of experimental methods, other than those furnished by nature in the course of ages; hence, as Osborn has indicated, the great importance of paleontological researches. At the same time, while the processes which change the fundamental character of animals and plants may be too slow to observe, it is not to be doubted that very much light may be obtained by the experimental method, if only by way of showing us what it is that has been evolved—a thing we seem not to have clearly known. If the control of orthogenetic changes is reserved, as it were, for the gods—and we, doubtless, should only make a mess of it—we may be well satisfied if we can take advantage of the oscillation processes, which experimental researches are showing to be far more extensive and much easier to control than had previously been suspected.

LOYALTY[1]

By Professor JOHN C. BRANNER
STANFORD UNIVERSITY

WHAT little I shall say is about personal loyalty. It is due myself that I should explain that the greater part of this address was written more than two years ago, and especially for my own students, who frequently have to meet certain ethical problems in connection with their professional work. Within a few months there has appeared a book upon loyalty by a distinguished philosopher[2] who deals with the subject in its broadest and best sense. I make haste, therefore, to say that I do not attempt to discuss the subject in any large sense. What I have to suggest is not spoken with the authority of the philosopher or with the philosopher's subtle reasoning. I can only give my personal impressions and views of the subject without regard to its philosophic bearings. I should add, however, that in Professor Royce's lectures you will find ably dealt with the many problems that naturally arise in connection with this subject. And whether you agree with all he says or not, you will find his book one of the most helpful and inspiring that has ever been published in our country.

I must premise also that what I say is said in a spirit of perfect frankness and on general principles, and has no reference to any particular occasions, circumstance or persons. The subject seems to be especially worthy of your attention just now because the habit of loyalty is one that may be cultivated during your student life; it certainly will not spring into full-fledged development at some future time when it happens to be wanted.

I am often asked about points of practical professional ethics, and it is chiefly in connection with this phase of the subject that I have thought that it would probably interest you. Loyalty is going to be an important factor in the making of your character, and even, if you care to look at it in that light, an asset in your profession, or in your business.

Perhaps I lay a little more stress upon this point because I come of a people who habitually place a high estimate upon every phase of loyalty. We seem indeed to have exaggerated or distorted ideas of

[1] An address to the student body of Stanford University, September 9, 1908.
[2] "The Philosophy of Loyalty," by Josiah Royce, New York, 1908.

loyalty, and we rather overdo the thing at times in the southern states where we keep up family feuds one generation after another, and vote with one political party all our lives through thick and thin. In his story of "Red Rock," Thomas Nelson Page expresses the more serious southerner's view when he says of the soldier, "It is loyalty, not success, that is knightly" (p. 145).

Without making any fine distinctions, I start with the proposition that loyalty is the most valuable attainment, if we may call it an attainment, or the most valuable trait of character, if that is a better name, that any man or any people can have in this life. And I challenge any one who questions this theory to put the matter to any test he chooses to apply from the highest moral standards down to the lowest commercial ones.

Now loyalty has to do with our relations to principles, to organizations, to communities and to persons. I would have it distinctly understood that I regard loyalty to a right principle as the highest type of loyalty, and the kind that must always be most satisfactory in the end. Practical illustrations of the importance of the professional forms of loyalty are constantly falling under our attention, and it is chiefly of these that I shall speak. These lower types consist in loyalty to organizations of various kinds and to individuals. As many people insist on the commercial standards of values let us see, if we can, what business men think of it.

When you get through your university studies and go out into the affairs of life, if you become employers of other men, you will lay great stress on the loyalty of those you have about you. You may not put it to yourselves in just this form, but if you are wise, you will none the less be influenced as much, or even more, by the loyalty of your employees than by any other one quality they may have. You will say of every man you engage: "If I can't trust this man to think of and work for my interests, I don't want him around, no matter how skilful he may be in his particular line of work."

If you seek employment under others you must surely count on having to meet this test yourselves, for this will be the unfailing attitude of your employers. And the more important the position you are to occupy the more weight will be given to this particular trait of your character.

The matter simply reduces itself to this, that a man who is not loyal is not wanted by anybody for anything.

In a business like that of mining, consulting geologist and the like, what do you suppose a man would be worth who was not loyal to the interests of his employer? How long would any one keep an employee who was not loyal? How long ought he to be kept?

Let us take a simple case: Imagine a man employed to examine and report on a given piece of property who sells or turns over to outside parties information belonging to his employer, or who uses it for his own personal ends. Can anything be farther from the object for which men are employed, more base, more dishonorable?

Let us have the opinions of men of wide experience. I once recommended a young man for the position of assistant to one of the leaders of science in this country, who wrote back to make further inquiries, and wound up with this: "I want a man who is orderly, interested in the work and who will devote himself to my interests. If he will *not* devote himself to my interests I don't want him, no matter how competent he may be."

Dr. Rossiter W. Raymond, the venerable secretary of the American Institute of Mining Engineers, a man who has perhaps had a larger, more varied and more honorable career in connection with mining operations in this country than any other one man, says on this subject:[3] "Loyalty commands to-day the highest price in the market:" and he says much more to the same effect.

In one of the large banking houses of New York City this notice is posted up in full view of prospective customers: "If you can't cooperate, don't come round."

A few days ago I saw a letter from the manager of one of the largest mining companies in the world which contained the following reference to a man who had not been loyal to his employer: "I personally consider that a pick and shovel are the only instruments a man should be allowed to use who abuses his employer's confidence."

I doubt if the man who says this would want such a person about him even to use his pick and shovel. For if a man is not loyal, no one trusts him, no one feels comfortable with him around, and no one wants him at any price, or for anything.

Loyalty is so highly esteemed by most people that one is ready to overlook slow head, slow hands and slow feet where loyalty exists, while without it no skill or agility of mind or body makes one a desirable employee.

In large enterprises where many men have to cooperate, the lack of loyalty throws all the machinery of organization and administration out of gear; nothing runs smoothly.

Employees, assistants, partners and colleagues are wanted to help, to render service, not to hinder, to bring disorder and disorganization into an enterprise, no matter whether that enterprise is a great industry or a small one, a club, a fraternity, an organization of any kind whatever. No institution can long survive without the loyalty of its members to the common interest and purposes of its organization, and to each other.

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[3] *Engineering and Mining Journal*, June 23, 1906, p. 1199.

It may occur to you that it is too much to ask that self-respecting men should fall down and grovel in the dirt at the feet of every selfish dollar-chasing employer. Nothing of the sort is expected. A loyal man can not only stand up straight, but he can stand just a little straighter than any one else, for no one so much as he has the mind conscious of rectitude.

You may fairly ask what is to become of loyalty when the conditions make it impossible. One always has a remedy in his own hands: he can quit, and carry with him a gentleman's self-respect, for without that there can be no loyalty worthy of the name.

There are certain things that loyalty does not demand of us. For example, it does not require us, in being loyal to one person, to be disloyal to others. Environment and education often lead us to look at things differently, and honest men may conscientiously differ, but we are bound to respect the attitude of other people, or as Professor Royce puts it, to be loyal to the loyalty of others.

Again, loyalty should not lead us into excesses that work wrong to others. It is a common misconception of loyalty to imagine that one must back his personal friend for anything and everything he happens to want, regardless of whether he is fit for it, and regardless of the rights of others. It is unnecessary to say that such an attitude is not tenable. Loyalty to the principles of justice and right will not permit that sort of thing.

But there are usually two parties to loyalty, especially in matters of employment and in all organizations where there are superior officers under their various titles or wherever the personal element enters. It can not all be on the side of the employee or of the subordinate. The employer, the head of the firm, the superior officer and the organization itself owes loyalty to employees, to partners and to colleagues. And it is this loyalty to each other that constitutes *esprit de corps*, that enables organizations to pull together, to work to a common end, to act in concert, to stand together in all things and to one big purpose. Moreover, those who expect loyalty are bound by every sense of decency and propriety to be worthy of loyalty, and to be loyal in return to those of whom loyalty is expected; that is a *sine qua non*. No one can long be loyal to a man who backbites, belittles or sneers at his employees or his colleagues behind their backs.

And what I say of loyalty is true not only here among us, in our own community, in our own country, and in our own time, but it is equally true of every quarter of the globe and of every age.

In commending loyalty to you I am not raising any questions about right and wrong. And even if I should raise such questions, there are, as Professor Royce points out, conflicting loyalties. I suspect that loyalty, like love, is blind. Who, when he sees his brother attacked, stops to ask whether his brother has the right of it? The loyal man simply says, "We'll settle that later, but for the time being I stand with my brother." And loyalty doesn't look to see whether the battle is to be lost or won.

Remember too that loyalty, like charity, begins at home. When can one see a finer sight than that of a family that stands compactly together, helping and encouraging one another within, and defending each other from without.

As students in this, to you, new community, I trust you will ever remain loyal to the high resolves you bring with you, loyal to the communities, the schools and the friends you have left behind, and that you may cultivate here a new loyalty to your *alma mater,* to your class, and to whatever organizations you belong, and above all loyalty to the purposes of your education. Never lose sight of the important fact, however, that loyalty demands submission to the rules of your order or organization; no properly constituted society will admit a member who will not subscribe to its constitution and by-laws. In practise you will not be called upon to do anything spectacular, but you will have to impress upon yourselves the necessity of steadfastness of purpose.

And don't expect too much of anybody. We are all human, and human frailties are in our blood and bones. Whether the object of your loyalty to a person, an organization, a party or a principle, you must not expect it to be perfect. None of the relations of this life are altogether satisfactory.

As a citizen be loyal to the legitimate and reasonable interests of the community in which you live, and you will not be found lacking in loyalty to the country at large. It is of loyal citizens and of loyal citizens only that great nations are made. Tyrants can not long oppress, nor can powder and bullets conquer, a people permeated with and true to such sentiments.

You will note that loyalty demands that you assume certain risks. This is inevitable. Loyalty without risks must be of a pretty poor quality. If there is anything especially pusillanimous in human nature, anything that one instinctively despises, it is the disposition to stand aside when there is danger to be faced, or to wait to see which side is going to win before choosing that particular side. Take the risks and go cheerfully forward.

Loyalty is one of the big and far-reaching virtues; it makes trustworthy men and great men; as a national virtue it makes a people great. For if it is love that makes the world go round, it is loyalty that holds the world together.

THE STORY OF PROFESSOR RÖNTGEN'S DISCOVERY

By ELMER ELLSWORTH BURNS
CHICAGO, ILL.

THE discovery of X-rays was announced by Professor Röntgen in December, 1895, in a communication to the Physico-medical Association of Würzburg. The date of the discovery is commonly thought to be November, 1895. As a matter of fact, the first X-ray photograph was made about two years before that time, and the accidental production of this photograph was the starting point of a series of investigations which continued for more than two years before the public announcement was made. The story was told to me by Dr. T. S. Middleton, now a physician in Chicago, who was a research student under Professor Röntgen during a period of four years, including the time when the great discovery was made.

Professor Röntgen is a man who works unceasingly as a teacher and in research, a man who brings to his students the inspiration of genius. Like Edison, he would often forget to eat were he not reminded by friends of his need of food.

He was working with cathode rays and, being an expert glass blower, prepared his own tubes. He had a habit of using his lungs as an air-pump in exhausting his tubes. Long practise had developed an athletic pair of lungs, so that he was able in this manner, aided by the increase in vacuum due to the electric discharge, to produce a vacuum sufficiently high for the production of the cathode rays. The first X-ray tube was exhausted in this way. This tube was blown to form a large bulb at the middle and bent to form a letter S at either end.

The electrodes being at the ends, the cathode rays would have to traverse the bends of the tube. Röntgen regarded the cathode rays as streams of electrified particles and believed that friction would be developed as these particles streamed past the bends of the tube. He expected this friction to result in new phenomena.

On a flat-topped desk in Professor Röntgen's private office lay an unassorted heap of books, glass tubes, photographic plate holders, platinum and aluminium electrodes, and what-not, such an unassorted heap as is likely to accumulate on the desk of a busy man. In this confusion it happened that a large book which the professor had been reading lay on a photographic plate holder. In the book lay a key serving as a bookmark. The use of a flat key as a bookmark is a peculiar habit of Professor Röntgen's, a habit which leads often to the finding of lost keys by shaking open the books on his desk. The professor was working with the Crookes tube referred to above, observing the beautiful yellowish-green fluorescence which characterized this particular tube, when his wife came to call him to lunch. Laying the tube, still glowing, on the book he obeyed her summons.

Now Professor Röntgen is an enthusiastic amateur photographer, in fact out door photography is his recreation. Returning from lunch, he took the plate holder which had lain under the book, with other plate holders, and made several outdoor exposures. On developing the plates a shadow picture of a key appeared on one of them. Much puzzled, he showed the negative to some of his students, asking them to suggest some explanation of the mysterious key. None of their suggestions proved satisfactory, and he was up early the next morning searching for a solution of the mystery.

He determined to repeat precisely the operations of the preceding day and, remembering the positions of the glowing tube, the book, and the plate holder, he placed them as before, leaving them for the same length of time as on the preceding day. On developing the plate, the image of the key again appeared. The key was found in the book but the mystery was not solved. Here was indeed a strange thing. Of course it was known that the cathode rays would affect a photographic plate, but here between the plate and the source of the rays were a book and the hard-rubber slide of the plate holder, both of which are impervious to light, and the cathode rays were confined by the walls of the tube.

Röntgen continued his investigations and found that the rays from his tube would penetrate other objects, but in different degrees, and because of this difference in transparency he could obtain shadow pictures of many interesting objects.

The fluorescence of his tube suggested to him that other substances than glass might be caused to fluoresce by the radiation from the tube. An interesting field was opened before him. Other research was suspended. Visitors were excluded, and with his research students the work was continued. Fluorescent liquids were tested, one of the first being a solution prepared from the horse-chestnut. The number of fluorescent substances tested, including liquids and solids, was not less than fifty. One of these was barium platino-cyanide, the fluorescence in this case being caused by the newly-discovered radiation acting through a black cardboard. Convinced by a long series of observations of the photographic and fluorescent effects obtained from his tube that he had discovered a new form of radiation, Professor Röntgen made his public announcement.

In answer to my question regarding the date of the incident narrated above, which marked the beginning of the great discovery, Dr. Middleton said that he had made no effort to remember the date. "Was it earlier than November, 1895," I asked? "Yes. It was at least two years earlier" and, recalling some incidents to aid in fixing to date, he continued, "It was soon after the opening of the autumn semester. It could not have been later than October, 1893. Possibly it was in 1892."

Professor Röntgen, being a reticent man, has not given to the world the details of his discovery. His announcement was that of results arranged in logical not chronological order. This narrative from an authentic source fixes the date of the discovery of X-rays at least two years earlier than that which is commonly accepted. Moreover, it shows us the great German professor in the light of a man who carefully and patiently worked out his problem to his own satisfaction before announcing his discovery to the world.

A GREAT PERMIAN DELTA AND ITS VERTEBRATE LIFE, WITH RESTORATIONS BY THE AUTHOR

By Dr. E. C. Case.

ASSISTANT PROFESSOR OF HISTORICAL GEOLOGY AND PALEONTOLOGY, UNIVERSITY OF MICHIGAN

As early as 1878 it was known that the remains of a wonderful group of animals lay hid in the rocks of north central Texas, that had lived their appointed time and passed away before the earth history was half completed; since then collectors have gone into this region more or less regularly, contending in the early days with hostile Indians and later with bad water and difficult transportation. Since 1895 the author has made several trips, gathering vertebrate fossils for the University of Chicago and the American Museum of Natural History in New York. The descriptions below are based on these collections and those of earlier workers.

Perhaps one can get the best idea of the age of the rocks and the fossils by remembering that they were laid down in the portion of geological time called the Permian age, just after the period of the coal deposition. Reckoning the completed history of the earth as about one hundred millions of years, these rocks and fossils are from thirty to forty millions of years old. At the beginning of the Carboniferous age, when the coal was laid down, the part of the continent that is now called the Mississippi Valley was covered by a wide sea, but during this age there was a progressive shallowing which culminated in the elevation of the Appalachian mountains in the east and the appearance of dry land from the new mountains on the east to the forebears of the Rockies on the west.

The appearance of dry land was at once the cause of the development of the wonderful group of Permian animals and the reason that so few are preserved to us, for it is only when the hard parts of animals or plants are buried in some water-soaked layer of the earth or are covered by water that they can be petrified and preserved. If they remain exposed to the air they are soon destroyed; so, of the skeletons of the thousands of buffalo left lying on the plains but a few years ago, there remain to-day but a few rotten and frost-split horns and bones. Undoubtedly in the muddy banks and bars of the rivers there are skeletons undergoing the slow process of petrifaction which will preserve them to be the chief treasure of some future museum. And so because of the land conditions which prevailed over so much of the continent the record of the great land fauna of the Permian age is very faulty and imperfect. It is only in some exceptional place where large quantities of bones were swept together under favorable conditions that they have been preserved and such an exceptional depository occurs in northern Texas.

When the Appalachian Mountains were raised an extension of their southern end reached across what are now Arkansas and Oklahoma, terminating in the Wichita Mountains in western Oklahoma. North of this range rose a broad upland reaching from the Rockies to the Appalachians and to the Canadian line on the north; south of the mountains a shallow sea reached nearly to their base, and some

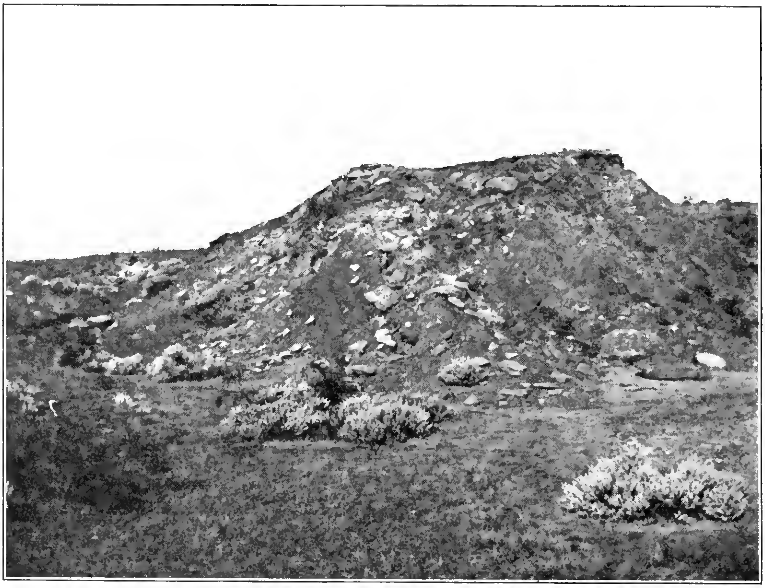

FIG. 1. VIEW IN WILLBARGER COUNTY, TEXAS, showing the character of the beds in which the bones occur.

great rivers, from the mountains and the uplands, poured their flood waters into the sea and built up a great delta. The remains of animals which haunted the banks of the rivers were swept into them in time of flood and carried out to be deposited in the delta, which covered most of what is now Wichita, Archer and Willbarger counties in the state of Texas. Naturally most of the remains which found their way into the streams were already fragmentary, as they had rotted on the bank and been torn by predatory animals, but in their course to the sea they were farther disintegrated, so that, rolled by the rivers and beaten by the waves, they sank to their burial as little more than water-worn fragments; ends of limb bones, isolated vertebræ and broken skulls which do little more than tantalize the student with the hints of new forms and new relationships which can not be verified. In some places these water-worn fragments are so thick upon the ground that they can literally be shoveled up by the wagon load. In some rare instances the bodies of animals found their way unharmed into the water and, distended by gases of decomposition, floated far and uninjured until they came to rest on some mud flat beyond the reach of sharks or other predatory animals. Such skeletons are preserved entire and in a most wonderful state of preservation, but they are exceedingly rare, not more than one turning up in a season's search.

Of all the wonderful animals revealed by their petrified remains, perhaps the most striking are the reptiles. The reptiles made their first appearance in the Permian or in the latter portion of the Carboniferous preceding, but here at the very inception of their line they developed a great diversity of form and habit. There were aquatic and terrestrial forms, carnivorous, herbivorous and omnivorous forms, forms simple and closely resembling their amphibian ancestors and forms so bizarre in their structure that the world has produced nothing more strange. The reptiles descended from the amphibians and it is natural to look in these beds, where the lowest of the reptiles are found, for the connecting link between the two, but as yet this form has not been discovered; the approach from both sides, however, is so close that it is frequently impossible to determine the nature of a specimen from a single bone or small portion of the skeleton.

The simplest of the early carnivorous reptiles were aquatic, living in the waters of the great rivers or perhaps even in the ocean. The body was long and slender and the tail was exceptionally so, in correlation with the swimming habit. Aside from the more technical points, the interest in the development of the primitive reptiles centers in certain changes of the teeth and the dorsal spines of the vertebræ. In one of the simplest forms, *Poliosaurus,* the teeth have the form of simple cones of nearly equal size in all parts of the jaw; such a dentition indicates that it preyed upon small animals which it seized and swallowed whole after the manner of snakes and many lizards. The dorsal spines are low and do not project beyond the skin. The animal probably resembled very closely the living monitor of the Nile.

In another and closely related reptile, *Theropleura*, the teeth have become differentiated, those at the anterior end of both the upper and the lower jaws, the incisors, are enlarged and have taken on the appearance of tusks; posterior to the incisors there is a slight notch in the edge of the upper jaw, caused by the growth of the lower incisors, and posterior to this there are tusk-like teeth in the upper jaw, the canines. The growth of the incisors and canines increased the power of grasping and holding prey. Moreover, in the posterior teeth of the

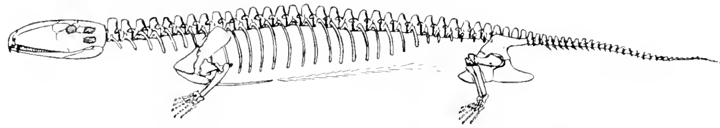

FIG. 2. RESTORATION OF THE SKELETON OF *Theropleura*.

jaws the teeth are somewhat flattened, so that cutting edges are developed which would lacerate the prey in capture or before swallowing and minimize the chances of escape. In *Clepsydrops* the dentition is still more specialized; the incisors and canines are longer and the notch between them has developed into a toothless diastema; the skull is rather thin and high and the eyes are located far back in the skull. The spines of the vertebræ are very high and project from the back like the fin of a fish, in this matter contrasting strongly with the simpler forms in which there is no such fin or frill. It must be remembered that the spines are connected directly with the vertebral column and are not simply developed in the skin as is the case with the fishes. In the modern *Basiliscus* and *Iguana* there are frills on the back, but the strengthening spines are dermal like those of the fishes.

In *Dimetrodon*, the last of the series, these characters reached their culmination. The incisor and canine tusks have attained a relatively enormous length and strength, and projected from the jaws as much as three inches; the diastemal notch is larger and deeper and the posterior teeth of the jaws are recurved and have sharp serrate edges so they had all the cutting power of a Malay kris. Could a more effective arrangement be imagined for the cruel business of capturing and holding living prey despite its desperate struggles? The spines on the back developed to enormous length and in some forms tapered to the slenderness of a whip lash. The tail was short and the feet strong and with well-developed claws, all going to show that the animal was terrestrial in habit. The largest species of *Dimetrodon* reached a length of about eight feet and was easily the largest, strongest animal of its time. We can imagine this fiercely carnivorous form crouching in the bushes or tall grass on the side of some stream and making a

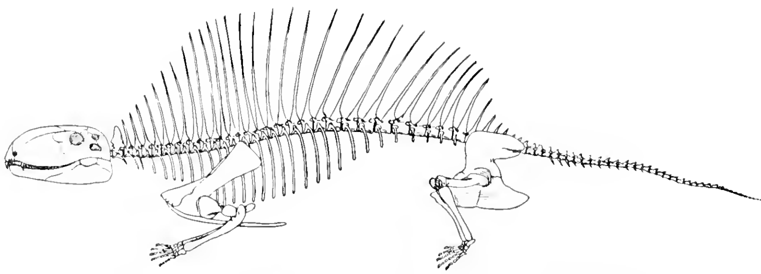

FIG. 3. RESTORATION OF THE SKELETON OF *Clepsydrops*.

fierce scuttling rush out upon its prey, perhaps some slow-moving reptile or amphibian, perhaps even some smaller individual of its own kind, for there is ample evidence that these animals waged fierce battles among themselves. It is not uncommon to find bones which have been broken during life and healed again, telling of furious reptilian contests in the struggle for mates or for territory, or perhaps with the single idea of a cannibalistic meal.

But a more wonderful animal still has left its remains in the rocks. In this form there were high spines on the back, but instead of the spines being simple they were furnished with projecting processes on the sides, not unlike the yard-arms of the old-fashioned sailing ships. This resemblance led Cope to call the animal *Naosaurus,* ship-lizard. In a recent restoration of *Naosaurus* it has been given the skull of the fiercely carnivorous *Dimetrodon,* the general similarity of the forms

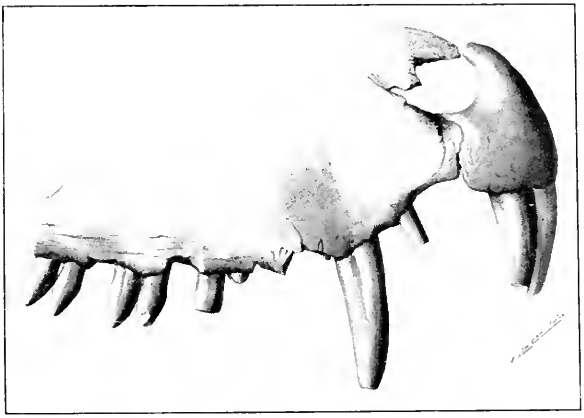

FIG. 4. ANTERIOR PORTION OF THE JAW OF *Dimetrodon,* showing the great tusks.

seemed to warrant this, but recent discoveries have made it probable that *Naosaurus* was not an eater of flesh, but a peaceful, sluggish eater of shell fish and perhaps of vegetation. This animal has perhaps the most wonderful dentition of any known animal the incisor teeth are sharp and chisel-shaped, such as might be useful in cutting strong vegetation; behind these are five sharp triangular cutting teeth, not unlike the sectorial teeth of such flesh eaters as the tiger and lion; behind these are simple cones, such as would be useful in holding a struggling victim. But most wonderful of all, on the palate and in a corresponding position on the lower jaw were heavy plates of bone, covered by short stumpy teeth, such as occur in the jaws of fish which live upon molluscs. The animal was seemingly omnivorous, but instead of having a dentition of a generalized pattern like that of the pig or the human being, there was a set for each kind of diet. The

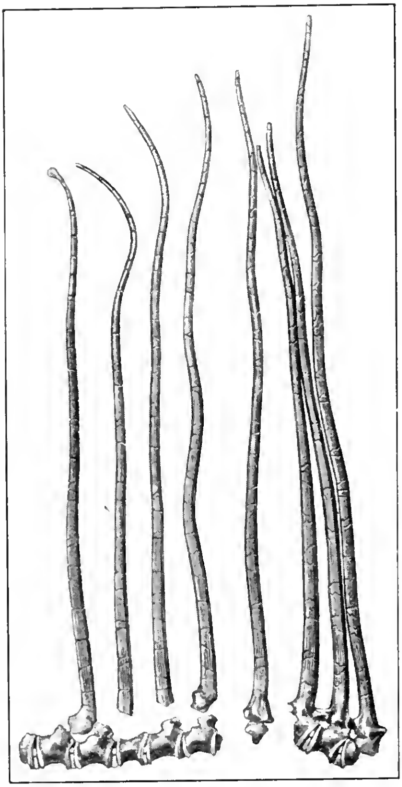

FIG. 5. PORTION OF THE VERTEBRAL COLUMN OF *Dimetrodon*, showing the enormous development of the spines.

discovery that *Naosaurus* was an eater of molluscs and not a predatory form makes more perplexing than ever the question as to the use of the spines on the back. On such a thick-bodied, sluggish mud-grubber, the cross-barred spines must have had about the same value as an ornamental frieze on a canal boat. What conditions of environment could have produced similar structures on creatures of such dissimilar habits as *Dimetrodon* and *Naosaurus?* It is as if the tiger and the badger should meet on common ground and develop highly specialized, unwieldy and seemingly useless structures of close similarity.

Of what use were the spines on the backs of these animals? The structure shows that they were not covered with flesh, but were united by a thin membrane through which the spines showed as plainly as the fin rays in the fin of a fish. It is hard to conceive of this great

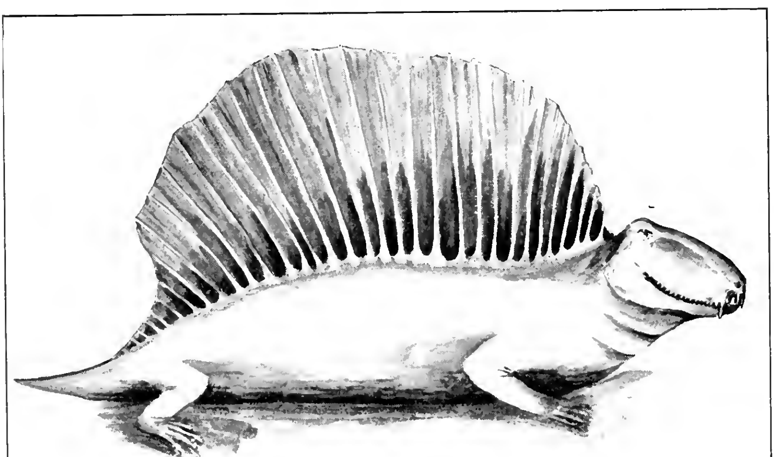

FIG. 6. RESTORATION OF *Dimetrodon*.

dorsal frill as anything but a hindrance to any quick movement. Cope suggested, in a spirit of fun, that these animals were the precursors of the modern fin-keeled yacht and that when they wished to navigate the Permian waters they swam upon their backs. Other authors have suggested equally abused uses in a similar spirit, but there are very few that can be considered with any degree of seriousness. The obvious suggestion is that the spines served as some form of protective mimicry, perhaps helping the animal to remain concealed among the reeds which bordered the lakes or streams, but this seems hardly necessary when we reflect that the animal was the dominant form of its time and needed no concealment unless it was to aid in lying in wait or in making an unseen approach until sufficiently near for the final rush upon its unsuspecting prey. This last is perhaps a fair suggestion, but it seems that the physiological burden of maintaining such an essentially weak structure must have far outweighed any conceivable advantage of concealment. The spines were slender and were constantly subject to fracture in battle or by accident and the animal must have expended no inconsiderable portion of its energies in repairing the broken structure.

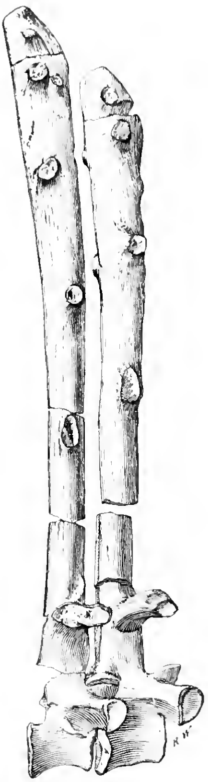

FIG. 8. SIDE VIEW OF TWO DORSAL VERTEBRÆ OF *Naosaurus*.

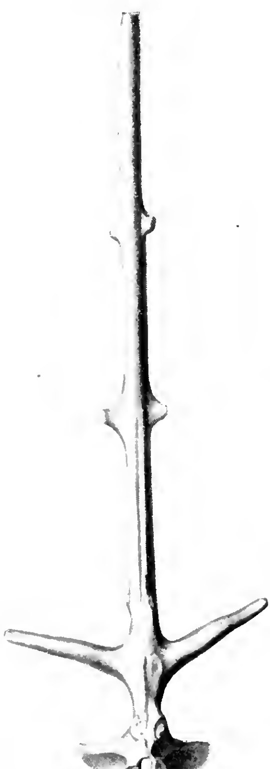

FIG. 7. FRONT VIEW OF ONE OF THE DORSAL SPINES OF *Naosaurus*.

There remains the suggestion that the spines are remnants of a formerly useful structure and their present condition is purely a physiological one due to overgrowth. It seems certain that when a structure has developed so far as to give an animal a great advantage it may continue to grow until it is rather a burden than a help. The structure starting as a protective feature may give the animal such an advantage that it is practically free from all its enemies and in this dominant or protected condition it may become over-nourished and the originally useful structures may continue to grow by a kind of inertia or momentum until they become greatly exaggerated masses of flesh or inordinately developed spines, horns, feathers, etc. Such a development seems to have occurred once and again in the history of the world, and the most bizarre types of life owe something of their condition, at least, to this principle. The late Professor Beecher, of Yale, has shown that there is a decided tendency, both in plants and in animals, for a species that is nearing the point of its extinction to develop a spiny or horny habit, covering itself with all sorts of excrescences, seemingly in an unregulated effort to find some condition which will prolong its existence. It is certain that these reptiles, dominant as they were, were rapidly completing their allotted span and as the end approached the spines grew ever heavier and heavier, until it seems plausible to suggest that they became at last a great drain on the animal's powers of nutrition and hastened in no slight degree the end.

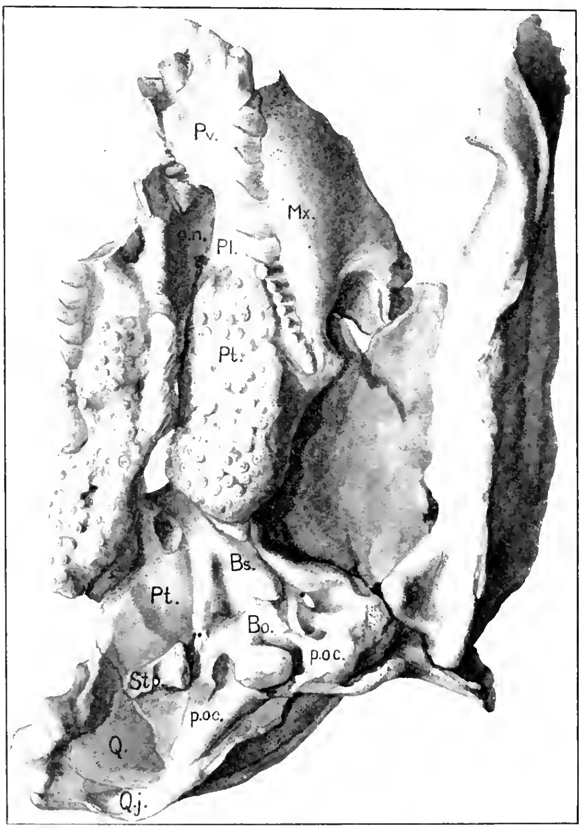

FIG. 9. PALATAL VIEW OF THE SKULL OF *Naosaurus*, showing the peculiar dentition.

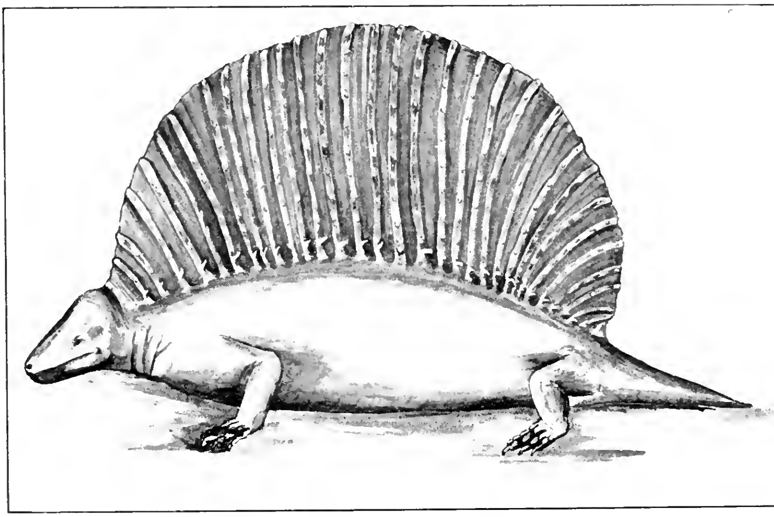

FIG. 10. RESTORATION OF *Naosaurus*.

The family of the high-spined *Pelycosaurs* did not monopolize the wonders of the reptilian horde; however the borders of the streams, the swamps and the uplands, harbored other forms whose structure is just beginning to be understood. One group of these, called by Cope the *Cotylosauria*, is the most primitive of the reptiles and the nearest to the amphibians. These animals were low-bodied and sprawling, with a head completely roofed over by bone and showing between the orbits the third, or pineal, eye. Rudiments of this third eye are still present in the human brain, the pineal gland between the cerebrum and cerebellum, and in many of the modern lizards it is still so far functional as to have a rudimentary retina perhaps capable of perceiving light.

Another group of reptiles closely resembling the *Cotylosauria* in outward appearance, but differing in many details, notably the development of a body armor, were placed by Cope in a separate order, the *Chelydosauria*. As indicated by the name, the *Chelydosauria* are probably the ancestors of the turtles. Aside from more technical points this relationship is shown by the development of a more or less complete carapace. The skeleton of the larger forms is pretty well known and the general shape is shown in the restoration of the skeleton of *Diadectes*, Fig. 11. The teeth are elongated transversely and flattened, telling of a purely vegetable diet; the dermal armor consisted of five overlapping plates on each side lying on the first five dorsal ribs; the anterior one is small, the second much larger and the last three smaller again. In certain small forms, *Otocœcus* and *Conodectes*, the armor was much more perfect, consisting of strong dermal plates correspond-

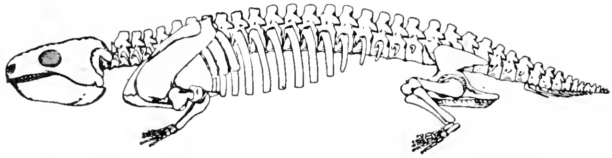

FIG. 11. RESTORATION OF THE SKELETON OF *Diadectes*.

ing to the ribs in number and extending down over the sides in broad curves so that the animal was completely closed in a bony cuirass. Add to this that the top of the head was heavy and solid, and we can imagine that the animal when it crouched close to the ground, with its head drawn down and in, resembled very closely the modern *Armadillo* in its attitude of defense and was able to resist the attack of even the long-tusked *Dimetrodon*.

This donning of armor is one of the striking things about the animals of the Permian age; it occurred among the amphibians as well as among the reptiles and is closely correlated with the development of great tusks in the predatory forms. As the armor-piercing weapons grew ever stronger the armor grew ever heavier and more completely adapted to the body. The same thing has happened once and again in the world's history; much later, in Tertiary time, when the world was thirty millions of years older, we have a repetition of the same thing. The great saber-toothed tiger developed canine tusks six inches in length, and the small edentates, the natural prey of the tiger, developed first small isolated bones in the skin, but ever as the tusks grew the bones in the skin became larger and better arranged, until the almost perfect protection of the *Armadillo* appeared. It was the prophecy of modern warfare between armor-piercing shells and armor plate, we have not seen the end in human history, but in the old days it continued to the practical extinction of both parties to the contest. Perhaps there is a neglected object-lesson here.

Turning from the reptiles to the amphibians, we find a no less wonderful group of animals. During the preceding age, the Carboniferous, the amphibians had been masters of the world; by the Permian, their time of dominance was past and they were already on the downward path that was to end in the obscure toads, frogs and salamanders of our meadows. But they were far from yielding tamely to their fate; they developed in all possible directions in a seemingly frantic effort to regain their lost dominance. During the Permian and the succeeding Triassic ages, there lived some of the largest amphibians the world has ever seen; they betook themselves to the water and developed eel-like bodies: they lived in hollow trees, as witness the discoveries of Sir Wm. Dawson in the stumps of trees

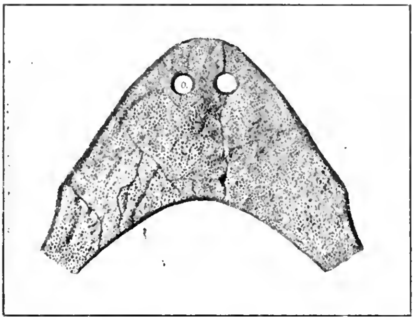

Fig. 12. Skull of *Diplocaulus*, showing the upper and lower surfaces.

Fig. 13. Restoration of *Diplocaulus*.

in the coal beds of South Joggins in Nova Scotia; they wrapped themselves in armor and they hid themselves in the ground.

It is possible to describe but a very few of the forms that are known. *Eryops* was the largest of the amphibian tribe, with a length of about eight feet; it was not unlike a great overgrown newt or salamander with weak sprawling limbs that could not raise the body from the ground, except by a great effort. The skull had a length of two feet and a half in the largest specimens and the lower jaw was hinged at the posterior end of the skull, so that the animal had a most tremendous gape. The jaws were armed with sharp conical teeth, which in the anterior portions of the jaws were developed into powerful tusks. Probably the animal played a somewhat similar part in the Permian waters to that of the modern alligator, lying nearly covered in the water with only the eyes and nostrils exposed, which were placed on the top of the skull for the purpose, and gliding slowly upon its prey until within a distance that made possible a sudden fierce rush which ended with the passage of the victim down the capacious maw of the *Eryops*.

Contrasted with *Eryops*, and probably frequently its victim, was the small *Diplocaulus*. Though still imperfectly known, enough has been made out about this animal to show that it possessed a form even more grotesque than that of the high-spined reptiles. The head, as shown in Fig. 12, was extremely flat and shaped like an exaggerated crescent with strong horns or spines projecting to the rear from the posterior corners. The eyes and nostrils were located far forward toward the anterior end and were directed straight upward. The lower jaw was very short and articulated with the skull far in front of the ends of the horns. No trace has been found of limbs, and the vertebræ interlock like those of the modern snakes; from this it is probable that these animals were limbless and snake-like in form, but they must have presented a most peculiar appearance with the slender body and enormous head. It is hardly possible that the animal could have raised its head from the ground except by an occasional and violent effort, for the skull was solid and relatively very heavy. Probably the animal was purely aquatic in habit and, lying in the mud of the bottom, wriggled forward, pushing its great head through the slime, from which it gathered the vegetation and small shell fish which formed its food. The position of the eyes and nostrils on the top of the skull renders this position the more certain. On the banks of the streams the amphibians took yet another form, for here they donned a complete coat of mail similar to that of the small reptile.

Imperfect as our knowledge still is of this wonderful group of animals, enough is already known to show how fully strife and warfare filled the world's history even at the beginning, and how every possible advantage of tooth or limb or armor was necessary for success.

THE PROGRESS OF SCIENCE

TWO GREAT UNIVERSITY PRESIDENTS

THE development of the American university during the last quarter of the nineteenth century is perhaps the most important chapter in our recent history. In this remarkable movement two institutions have led, and their prominence is personified in two great educational leaders, President Eliot, of Harvard, and President Gilman, of the Johns Hopkins. The oldest of our universities, with its high traditions, its faculty of eminent scholars and its alumni throughout the country, and the youngest of our universities, unentangled by precedents and engagements, free to plan its work and choose its

PRESIDENT CHARLES W. ELIOT.

President Daniel C. Gilman.

men, were the institutions best placed to lead the way, but they might not have done so had they not found the right presidents at the right time. From the point of view of this journal it is worth emphasis that both owed their preparation to scientific training and teaching. Dr. Eliot was professor of chemistry at the Massachusetts Institute of Technology when called to the presidency of Harvard, and Dr. Gilman was professor of geography at Yale when he took up administrative work.

Dr. Gilman resigned the presidency of the Johns Hopkins in 1901, on reaching the age of seventy years and after twenty-six years of office. His death last month recalls vividly his great services to higher education. Dr. Eliot has now resigned the presidency of Harvard to take effect next spring, when he will have served forty years in the office, and will be in his seventy-fifth year. Mr. Gilman was at the time of his resignation in full vigor of body and mind and was able afterwards to undertake the difficult task of organizing the Carnegie Institution, while performing many other public services. President Eliot has never seemed more competent to direct the affairs of a university than at present; there has not during the past forty years been a time when he has been so gladly followed as a leader. He is likely to remain for years to come the chief influence at Harvard and the leading private citizen of the United States.

At the inaguration of Mr. Gilman as president of the Johns Hopkins University on February 22, 1876, Mr. Eliot said: "In the natural course of your life you will not see any large part of the real fruits of your labors; for to build a university needs not years only, but generations." This is only partly true. The traditions and ideals of the university are a long growth, but they may be transplanted to a new soil and flourish there. Relatively to other institutions at least, it is probable that the Johns Hopkins will never again be so great as it was in the eighties, and Harvard will never again be so preeminent as it is at the close of Mr. Eliot's administration. The seven professors on the faculty of the Johns Hopkins at the beginning far surpassed the average of any present faculty, and the hundred students in the early years, the average of any present student body. This great feat was again repeated by Mr. Gilman when the medical school was organized. Harvard has accomplished more in the past forty years than during the preceding centuries of its history. It set standards of freedom and culture when such standards were most needed. It now shares its leadership with other institutions and will probably fall behind the greater of the state universities.

There is more instinctive admiration for the puritan aristocrat than for the opportunist, but in so far as Mr. Eliot stands for the plan of free electives, for culture prerequisite to the professional school, and Mr. Gilman for a group system of studies leading chiefly to the professional school and research, the majority of scientific men will side with the latter.

Mr. Eliot's position could only be filled by a man of equal distinction after forty years of service. It is probably well that it can not be filled. The constitution of the state of Massachusetts places measures before men. It is better for the university to be a democracy of scholars, rather than for its scholars to be subject to the will of one man. The Harvard corporation will not purposely reorganize the university on a democratic and representative basis, but they will probably contribute to this end by the president whom they will elect.

SCIENTIFIC ITEMS

We record with regret the death of O. T. Mason, head curator of anthropology in the U. S. National Museum; of Dr. Francis H. Snow, formerly chancellor and professor of entomology in the University of Kansas, and of Professor Berger, the eminent French surgeon.

There was held at the Sorbonne in Paris, on October 4, a meeting in memory of the great chemist, Marcellin Berthelot. M. Raymond Poincaré made an address on his work, and was followed by M. Fallière, president of the Republic.—A bronze tablet to the memory of the late Major James Carroll, eminent for his work on yellow fever, was unveiled in the main medical building of the University of Maryland, on November 11. Dr. William H. Welch delivered the principal address.

SIR ARCHIBALD GEIKIE,
The Eminent Zoo'ogist, elected to the Presidency of the Royal Society.

By the will of the late Grace M. Kuhn, Harvard University receives $175,000 to endow a department of biological chemistry.—The Draper's Company will erect for Oxford University an electrical laboratory at a cost of £22,000 and will give an additional sum of £1,000 for its equipment.

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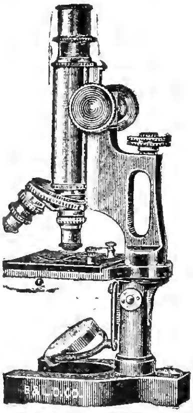

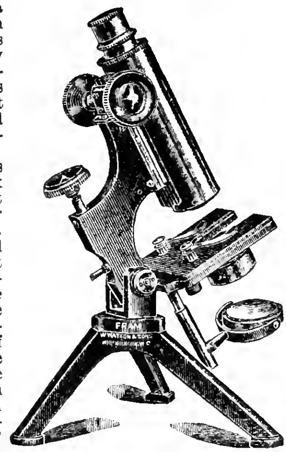

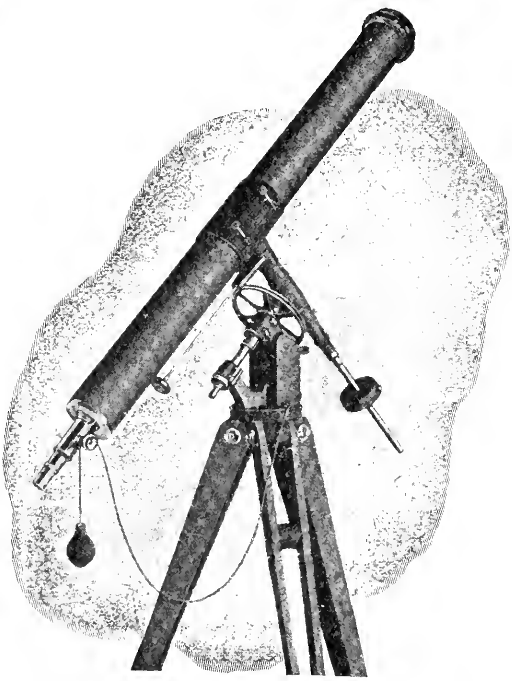

Illustration shows 5-in. with pneumatic clock.

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