THE POPULAR SCIENCE MONTHLY

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THE
POPULAR SCIENCE
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JANUARY, 1906

WITH THE BRITISH ASSOCIATION IN SOUTH AFRICA

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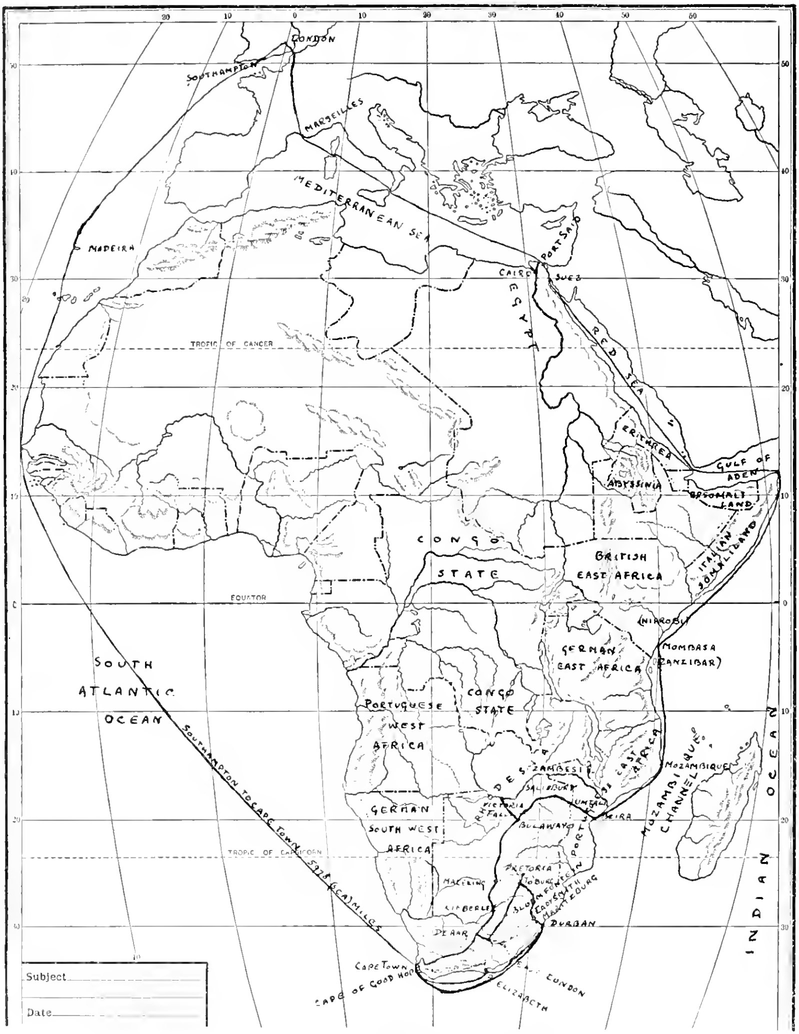
I.

THE visit of the British Association to South Africa during the past summer appears to have established the idea that its activities in future are not to be confined to the British Isles. Two successful oversea meetings had already taken place: the first at Montreal, in 1884, and the second at Toronto, in 1897, and there seemed to be no reason why the suggestion of a meeting in Cape Town, made as far back as 1898, by Sir David Gill, astronomer royal at the Cape, should not be followed up. But there were many difficulties in the way. It was obvious at the outset that few would be willing to make two long journeys by sea unless opportunities were afforded to visit the chief places of interest in other parts of South Africa. It was obvious too that few of those whose presence was chiefly desired would be in a position to afford the necessary expense unless very considerable assistance were forthcoming, and the general funds of the association were not intended, nor were they sufficient, for this purpose. Further, there are few towns where accommodation for several hundred visitors can be obtained, and this meant that special trains with dining and sleeping cars must be provided; the trunk lines in the colonies have a supply of rolling stock not much more than is sufficient for the few who travel long distances in South Africa.

While the matter was under discussion, war broke out. But those who were interested did not lose sight of the idea, and early last year it took more definite shape in generous offers of assistance from the governments and towns in South Africa. In the meantime, many changes had occurred. The new colonies must be included in the itinerary; opportunities must be afforded to see places and districts rendered famous during the war; the extension of the main line in Rhodesia to the Victoria Falls made a visit to this natural wonder almost a necessity; and the recent connection of the port of Beira in



SCALE. ABOUT 750 MILES TO THE INCH.

The main routes are marked with a thick line ——

Alternative routes by dotted lines . . . .

The dot and dash lines —·— · show political boundaries.

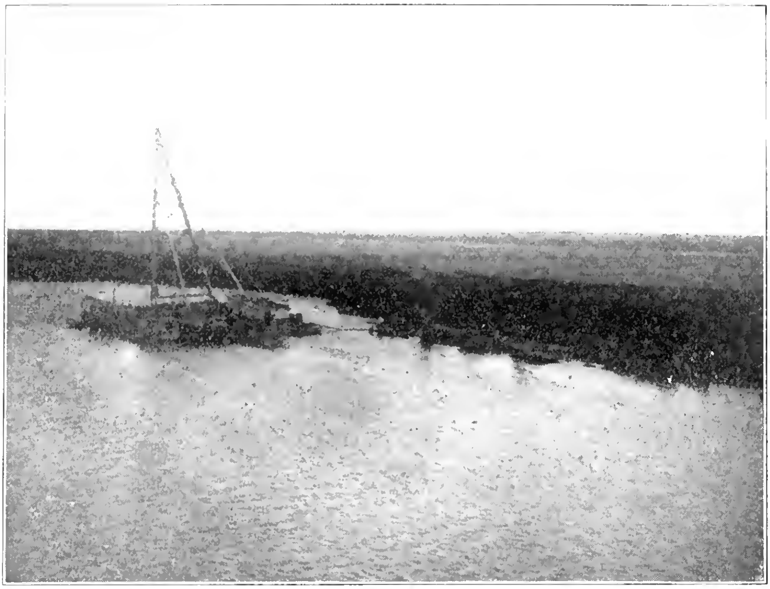
This map of Africa is copyrighted by the McKinley Publishing Company, Philadelphia, and is printed here by their courtesy.

Portuguese territory with Bulawayo suggested a possible return by the east coast and through the Suez Canal.

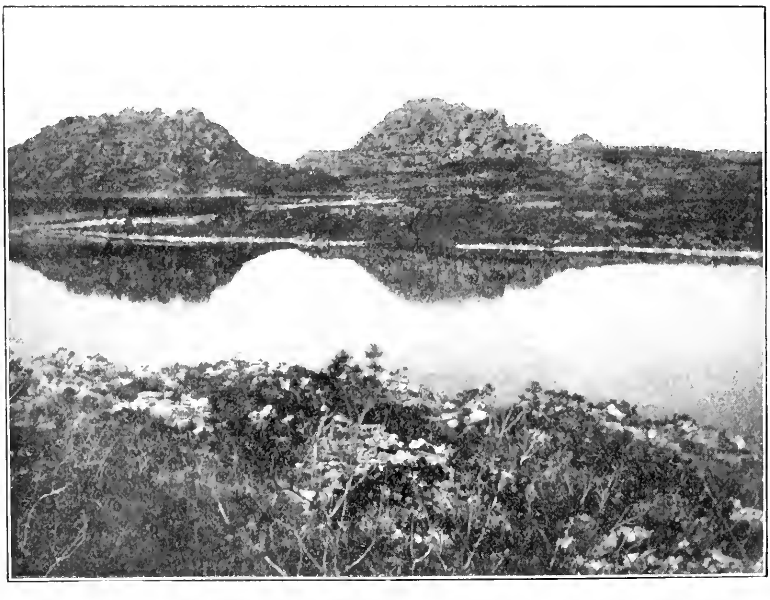
The tour finally planned was an extensive one, as a glance at the accompanying map will show. The Union-Castle line steamers *Kildonan Castle* and *Durham Castle,* leaving Southampton on July 22, and the *Saxon,* leaving on July 29, carried the members over the 6,800 miles which separate that port from Cape Town. From there the party traveled by sea or rail to Durban and thence by rail to Johannesburg, making stops at Pietermaritzburg, Colenso and Ladysmith. The scientific meetings were divided between Cape Town and Johannesburg, and four or five days were accordingly spent in each of those towns. After a short visit to Pretoria, the regular program involved a long journey of 1,374 miles to Bulawayo *viâ* de Aar Junction, the only possible all-rail route; on the way, stops of a day or two were made

General View of the Victoria Falls from a Point near the West End.

at Bloemfontein and Kimberley. From Bulawayo five special trains conveyed the oversea party, with the addition of many others living in South Africa, to the Victoria Falls, where a couple of days were spent. On the return to Bulawayo about half the party proceeded direct to Cape Town, whence the regular steamers carried them by the west-coast route to England. The remainder went by rail through Salisbury and Umtali to Beira, where the *Durham Castle* awaited them for the east coast route. On the return journey, Mozambique, Mombasa and Cairo were visited; the presence of plague at Zanzibar and Niarobi upset the arrangements for seeing those two places, but the unexpected block in the Suez Canal enabled the party to spend much more time in Egypt than had been expected. Several members whose duties



THE SPOT IN THE SUEZ CANAL WHERE THE 'CHATHAM' WAS BLOWN UP, causing the Canal to be blocked for over two weeks.



CHARACTERISTIC KOPJES AND A PART OF ONE OF THE RESERVOIRS ON TABLE MOUNTAIN.

called them back early left by the quickest routes from Cairo, many others disembarked at Marseilles, the final port of call, and the remainder proceeded with the ship to Southampton, which was reached on October 24.

The route thus outlined was admirable for seeing as much as possible in the time, thirty-five days, which could be spent in South Africa. But many of those who went out had more specific objects in view than attendance at the meetings or sight-seeing, and arrangements were accordingly made so that any one could deviate from the official route and travel by the ordinary trains. Some went to Durban by the only railway route—through Johannesburg; others omitted Natal altogether and spent the extra time examining the geological and botanical features of Cape Colony and the Orange River Colony; some avoided a great part of the long ride from Johannesburg to Bulawayo by going on 'trek' from Potchefstrom, or from Pretoria, to Mafeking; other parties trekked from Bloemfontein through Paardeberg to Kimberley; and so on. And in each case something new and definite was to be seen or learnt.

Everywhere the arrangements made by the local committees were admirable. When it is remembered that about 360 people from Europe landed in Cape Town and were carried over an immense extent of territory, were lodged and fed everywhere in comfort and without going through any hardships beyond the fatigue caused by such rapid traveling, and this almost without a hitch of any sort, one can not too highly praise the ability and devotion of all those who were responsible for the organization. And it must be added also that it was not only those who kept to the official route who were alone considered. At every place efforts were made to find out what the various members wished to do and, if possible, arrangements were made to accommodate even a small number; alternative excursions were described in printed circulars, previously distributed, and all that was asked was for each member to apply at the committee room for tickets, so that the number joining any particular excursion might be known. At every place where a stop was made each person knew in advance where he or she was to stay, and conveyances and guides were ready at the station so that there should be no delay or confusion. For example, all that was asked of us at Johannesburg was to stand at the windows of our own compartments as the train steamed into the station, and when the train stopped each host was found standing on the platform opposite his guest. Our baggage, previously directed, arrived later in the day, and meanwhile we were driven, first to the committee room, where we made the circuit of a long counter, gathering up handbooks, tickets and mail, and then to our destinations. And so it was everywhere. No matter seemed too small for consideration and preparation. Many of us felt that perhaps the most striking feature of the tour was the excellence and elasticity of all the arrangements made for our comfort and convenience. If the ability shown by the colonists in this direction is any guide, one should not fear much concerning the administration of the colonies in the future.

In order to secure the attendance of those whose presence was chiefly desired from the scientific side, a fund of over nine thousand pounds was raised, mainly by contributions from the governments of Cape Colony, Natal, the Transvaal and the Orange River Colony, and supplemented by subscriptions from private individuals; this was used to pay the greater part of the expenses of the 'official members.' The governments also issued free passes over railways to all oversea members, and the Rhodesian railways gave a large number for the use of the official party and tickets at half fares for all others. At those places where a stay was made entertainment was provided for the official party, either in private houses or as guests in the hotels; in some places all the members were similarly treated. Most of the excursions were free to those who chose to take advantage of them. It is a privilege to have an opportunity of saying in public what all of us felt, that the generosity and hospitality displayed by the residents of every town far exceeded our utmost expectations, and the kindness which we received is not likely to be soon forgotten. This too in a land only beginning to recover from the ravages of civil war, suffering from a two years' drought, with nearly all its cattle exterminated by disease, and in the height of the most severe financial depression it has known for twenty years.

The official party, numbering about 180, consisted of the president and general officers of the association, the president, a vice-president and a recorder in each section, a number of prominent scientific men, not necessarily officers, and some younger men of promise and ability selected by the general committee. The ladies who accompanied the official members were also attached to the official party. Finally, representatives of other countries were invited to joint as guests of the association. They included Dr. Backlund, from Russia; Professors Beck, Engler, Harzer and von Luschan, Germany; Professor Böhr, Denmark; Professor Cordier, France; Professor Donner, Sweden; Professor Penck, Austria; Professors Kapteyn and de Sitter, Holland; Mr. D. Randall MacIver, Egypt; Professors Macallum, Coleman, J. B. Porter, Canada; Professors D. H. Campbell, H. S. Carhart, W. M. Davis, W. B. Scott and E. W. Brown, United States; and others who were not able to attend.

The general officers of the association for the year are: President, Professor G. H. Darwin (now Sir George Darwin, K.C.B.); secretaries, Major P. A. Macmahon, Professor W. A. Herdman; treasurer, Professor John Perry. The presidents of the various sections are as follows: A (Mathematical and Physical Sciences), Professor A. R. Forsyth; B (Chemistry), George T. Beilby, Esq.; C (Geology), Professor H. A. Miers; D (Zoology), G. A. Boulanger, Esq.; E (Geography), Admiral Sir W. J. L. Wharton; F (Economic Science and Statistics), Rev. W. Cunningham; G (Engineering), Colonel Sir C. Scott Moncrieff; H (Anthropology), Dr. A. C. Haddon; I (Physiology), Colonel D. Bruce; K (Botany), H. W. T. Wager, Esq.; L (Educational Science), Professor Sir Richard C. Jebb. Amongst others who attended and who are not included in the above lists or in the list of lecturers given below may be mentioned Sir Benjamin Baker, Sir T. Lauder Brunton, Professor John Milne, Dr. J. A. H. Murray, Sir W. H. Preece, the Earl of Rosse, Alexander Siemens, Esq., and Dr. A. Traill, provost of Trinity College, Dublin.

II.

To one accustomed to the rush of the high-speed boats on the north Atlantic, the rows of huddled up and miserable passengers lying in deck chairs, the cold winds and the frequent bad weather, a journey in a mail steamer crossing the equator presents a pleasing contrast. There is a general air of sociability and comfort; sports, tournaments

SOME OF THE MEMBERS ON THE 'SAXON' before the ship left Southampton. In the top row, reckoning from the right, may be seen Prof. and Mrs. Herdman, Prof. Forsyth, Mr. Freshfield, Sir R. Jebb, Sir W. Wharton, Dr. Murray; in the second row, Dr. Haddon, Professor Perry, Sir W. Crookes, Sir L. Brunton, Major Macmahon, Mrs. Darwin; in the third row, the writer, Professor Darwin and Professor Sollas.

and entertainments of all kinds are of daily occurrence; and to these diversions were added in our case, as befitted the character of the company, lectures and discourses on subjects which were generally connected with the countries to be visited. But perhaps the most useful feature of the voyage was the opportunity it afforded for the leisurely discussion of scientific and professional matters and for establishing closer personal relations between men representing various departments of science. It need hardly be said that this was very fully appreciated, especially by those who have their work in places remote from the main centers of intellectual activity.

EUPHORBIA "SNAPPED" FROM THE TRAIN NEAR DURBAN

The southern gateway of Africa is an imposing sight as it is approached from the sea. A characteristic feature of the mountains, the table-like formation with high vertical cliffs on one side, has no better example than the huge mass which faces Table Bay, flanked on one side by the conical hill known as the Lion's Head, and on the other by the Devil's Hill. Cape Town lies on the low ground in front of the mountain and one can not see the old and new fortifications guarding the entrance to the docks without remembering its early settlement by the Dutch, its later acquisition by the English and the fact that, until the completion of the railways to Durban, Delagoa Bay and Beira, the story of South Africa is almost contained in that of Cape Town. All through the late war it was the principal port of entry for men and supplies and during that time was a scene of tremendous activity. It is now suffering from severe depression caused by over-speculation in building and commerce. In spite of the fact that the population of the whole colony is less than 600,000 whites, trading was started after the war on a scale which a white population of twenty millions would hardly have justified. As might be expected in a town of nearly 80,000 inhabitants, Cape Town has the conveniences of a modern city, a fine town hall just finished at a cost of a million and a quarter dollars, a good and plentiful water supply, electric light, extended railway and trolley car lines, and a perfect sewerage and drainage system.

It is not possible for me to warn intending tourists of the troubles caused by quarantine, customs declarations, passports or baggage transport, for all these formalities were dispensed with: we had only to walk ashore in company with our hosts who had come on board the ship to meet us. The first half of the presidential address was delivered by Professor Darwin on the evening of arrival, and the following three mornings were devoted to the sectional meetings. The five days in Cape Town were spent by the different members of the party in different ways, according to their consciences or inclinations. The afternoons were generally free for excursions, and the evenings were fully occupied by receptions or lectures, well attended by both visitors and residents. Many of the geologists were attracted by the opportunity to see the country with their own eyes and obtain data for the discussion of those problems which appear to be peculiar to South Africa. The astronomers were particularly active both in Section A and in afternoon and evening visits to the observatory, the history of which furnishes remarkable examples of devotion to science; under the present director it has not only been equipped with some of the finest and most modern instruments, but has sent forth many valuable contributions towards our knowledge of the heavens. Groote Schuur, the residence of Cecil Rhodes and bequeathed to the colony at his death, was a center of interest as the home of the man 'who thought in terms, not of countries, but of continents,' and nearly every one visited the beautiful house and extensive estate with its large collection of African animals. On the last day some hundred and fifty of the party, guided by members of the Cape Mountain Club and others, climbed up various routes on to Table Mountain and sat down to a lunch provided by the mayor near the new reservoirs which supply the city with water. There were excursions also to various features of interest in the town and its neighborhood, to the De Beers Explosive Works, to the Government Wine Farm at Groot Constantia, to the Admiralty Works at Simonstown, and to the Elsenburg Government School of Agriculture at Stellenbosch.

III.

The southeast coast railway to Durban is as yet incomplete and, to avoid the long railway journey *viâ* Johannesburg, the members left

Cape Town by the *Saxon* on August 18, calling at Port Elizabeth and New London, or by the *Durham Castle,* leaving the following evening and going direct to Durban. The times were so arranged that every one arrived there on the morning of Tuesday, August 22. There is practically only one good natural harbor for ships of large tonnage on the east coast of South Africa—that of Delagoa Bay, in Portuguese territory. Much money has therefore been spent in improving the harbor at Durban by building a long mole and by dredging the shallow channel which leads into a large protected lagoon. It is now possible for the mail boats to go inside and tie up alongside of the quays. One

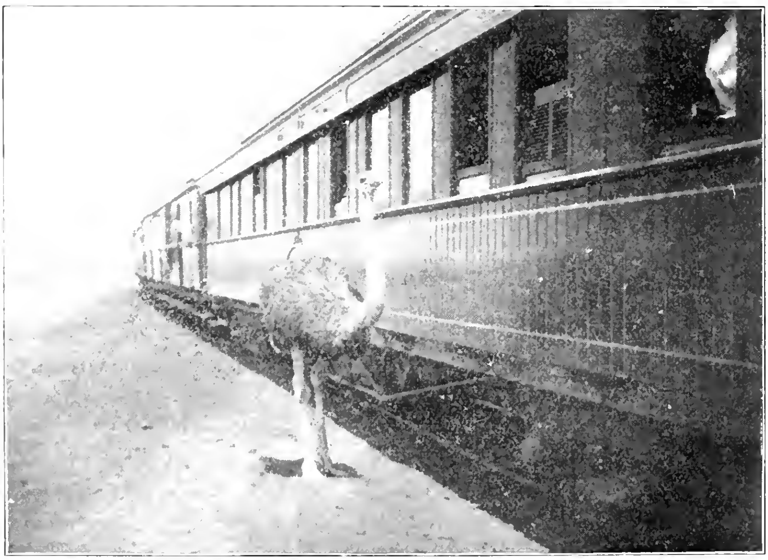
THE CHIEF PRINCESS OF THE TRIBE WHICH GREETED THE PARTY AT MOUNT EDGECOMBE.

was struck immediately on landing by the mixture of the east and the west. Jinrickshas drawn by Zulu boys with their picturesque head-dresses, ordinary two-horse carriages, and electric cars on the trolley system carried the passengers along well-made roads bordered by trees, to private houses and hotels, where they were waited on by Indian servants. Shops of all kinds, a big department store, English churches and chapels, a synagogue, a mosque, three-storied residences, bungalows—all these made it difficult for us to realize that we were in a town which has been British territory since its foundation in 1823. As at Cape Town, there were receptions, lectures and excursions to the more interesting works of nature and man. There were only two days allotted to Durban and the majority of the party spent the greater part of one of them at Mount Edgecombe, some fourteen miles away, where the factory of the Natal Sugar Estates is situated. The company had issued an invitation for lunch and an inspection of its works, and it had also made arrangements for us to see something of the native element by gathering together over 300 Zulus from the surrounding country. The exhibitions of war and other dances which we witnessed were much appreciated by the ethnologists and photographers. I may mention here that over a hundred cameras were continually employed on all varieties of subjects throughout the whole of the trip. In order that a record of some permanent value may be obtained, it has been proposed to make a selection of photographs taken by those who are willing to lend their negatives and to publish a memorial volume containing the best of the pictures.

THE BRIDE, BRIDESMAIDS AND INDUNA. Mr. Samuelson is standing on the right.

An even more interesting view of native customs was obtained in an excursion to the large Henley reservation near Pietermaritzburg, our next resting place. Maritzburg, as it is generally called, lies in a basin surrounded by hills and is laid out on the Dutch plan, in blocks like an American town, with broad avenues, but with houses which, like most of the residences in South Africa, are only of one story. The reservation is on higher ground and the station is less than ten miles away as the crow flies, but requires a journey of seventeen miles along a railroad with steep grades and sharp curves. The only white man living on the reservation is the permanent undersecretary for native affairs, Mr. Samuelson. By his wish, the marriage ceremony of one of the native chiefs, Mhlola, the head of the Inadi tribe, had

STREET IN MARITZBURG.



A VISITOR DURING A HALT BETWEEN MAFEKING AND BULAWAYO.

been postponed in order that the association might have the opportunity of witnessing it. The bride, who is to be Mhlola's chief wife, is a 'commoner,' contrary to the usual custom. It is probably the only occasion that a royal Zulu wedding has been attended by a large party of invited guests of the white race. We watched the official part of the ceremony for some three hours; dances, speechmaking and chanting of war-songs not unlike Gregorian chants occupied most of the time. The part of the ceremony which constituted a legal marriage was followed by the presentation of gifts from the bride to her husband's principal female relatives and of symbolical presents to the bridegroom consisting of a lamp, a water jug, basin and soap, a chair and an umbrella. The festivities were to last two or three days, but the members of the association had to leave for other scenes, and they preferred the conventional lunch provided by the residents of the city to the oxen roasted over open wood fires and the Kaffir beer in which the natives delight. This attractive program occupying the only full day spent at Maritzburg prevented many of the visitors from joining in the numerous other excursions which the hospitable residents had arranged. Some idea of our activity throughout the trip may be gathered from my movements on the previous day. Leaving Durban at 8:50 A.M. and reaching Maritzburg at 1:10 P.M., I spent the early afternoon in riding round on the electric cars, seeing the town and visiting the new botanical garden. Then to a garden party at Government House, and after dinner to a lecture on 'Sleeping Sickness,' by Colonel Bruce!

It was a fortunate circumstance that the third volume of the *Times*' history of the Boer war, containing a full account of the operations round Ladysmith, should have been published early in the year. Those who had read it during the outward voyage were able to picture to themselves the various incidents of the struggle as the trains slowly steamed through the area past Estcourt, Frere and Chiveley, to Colenso. An afternoon was spent in climbing the nearer hills of Fort Wylie and Hlangwani, and in viewing the devious course of the Tugela as it threads its sunken bed through the rolling ground lying in front of the round-topped hills which faced the army at Colenso. Stone sangars, but little damaged, are still to be seen on every hand, but the hunters of curios in the shape of bullets and portions of shells had done their work too well long before our arrival, and few relics were discovered. Here the special trains were side-tracked for the night so that the points of interest along the short distance to Ladysmith could be seen by daylight. The residents of this quiet country town lying in a warm hollow on the Klip River had gathered together every available private and public conveyance and drove us to the scene of the most famous incident of the siege, Wagon Hill. This spot, about three miles from the town, commands it completely, and had the Boers in their determined attempt on January 6, 1900, succeeded in capturing the hill against the desperate defense made by the British, it would have been necessary to retake it at all costs or to evacuate Ladysmith. Another hill of historic interest, Spion Kop, some eighteen miles distant, was visited by a small party who had gone on ahead for the purpose. The town itself bears few marks of the siege. The hole made by a shell in the clock tower of the town hall is still unrepaired, doubtless for the sake of tourists. I noticed the remains of a few of the 'dug-outs' in the steep crumbling banks of the river, and some of the corrugated iron plates which form the walls of a freight shed at the railway station had many bullet-holes in them; they had been evidently used for cover and returned at the end of the siege.

The day at Ladysmith was followed by a night's journey to Johannesburg. The higher veld is reached along a series of heavy grades, frequently one in thirty. There is no attempt to make the line straight; tunnels, embankments and cuttings have been avoided as far as possible to save expense, and the line, especially over rolling plains, closely follows the natural level of the land. Over a thousand feet of height is gained near the border of the Transvaal by a series of zigzags up the side of a mountain; at each of these the line comes to a stop, and the train is reversed up the next portion, and then forward again after another stop. There is apparently no hill around which the line may curve easily in order to obtain the desired height.

IV.

Although Johannesburg has been so often described, I can not pass in silence over this focus of all the later development of the Transvaal and of most of its political difficulties during the last twenty years. Moreover, so many changes have taken place since the war ended and so much misconception still prevails about the conditions there that it is only right and perhaps not uninteresting to record the impressions of one who was anxious to learn the facts and who had various opportunities for obtaining accurate information at first hand. The most striking and noteworthy of these impressions was the absolute openness of everything connected with the mining industry. Not only have very full reports of the working of each mine to be sent in monthly to the government and to the Chamber of Mines, but every new process, every improvement in machinery, every new problem arising, every difficulty occurring in the management of the natives and Chinese, is known or can easily be found out by those living on the Rand. And this is true not only of the residents, but also of any visitors who may wish to learn the facts and will go to the proper sources for them. In our case, the chief desire seemed to be that we should get to know what the actual conditions were, the bad as well as the good side; it was not a question of searching for information, but of listening to the full answers which an enquiry always produced. In particular, the native and Chinese compounds were visited at all hours both with and without previous notice. My own impressions and those of our party with whom I afterwards talked were the same: that the arrangements for housing and feeding the workers are far better and more complete than we had any idea of, and that the slavery which has been and is still so much exploited in meetings and newspapers of a certain class does not exist. Passes for leaving the compounds during off hours are freely granted to natives and it is only since the commission of crimes outside by a few bad characters that a restriction in this direction has been placed on the Chinese. As one walked about the compounds or in the mines underground the solemn Chinese equally with the light-hearted native readily responded to a word or a smile. 'Tell those who abuse us to come and see things for themselves'—was a frequent remark from the mine officials with whom I talked.

A second striking feature is the change which must have come over the spirit of the so-called 'Outlander' since the conclusion of the war. Formerly, Johannesburg consisted of the business section, the mines with compounds for the natives, and cottages on the mining area for the staff and white workers. During the last three years large suburbs have sprung up with many hundreds of residences surrounded by gardens and young trees, and having every appearance of permanent occupation. If this conclusion is correct, there will be a large settled population within the city area which will take an interest in its future and in the general affairs of the country, in spite of the fact that the majority of the shares of the mining companies are naturally owned in Europe, whence came the money which started them. To this must be added the consideration that nearly all the best work on the mines is being done by comparatively young men who have gone to them with the definite intention of making a living, and who have to use all the ability and energy they possess to rise to the higher positions. There is need now, however, of men of a higher grade, with, if possible, a college education and special training in some one or more of the departments connected with mining.

As might be expected, the town gives every external appearance of being alive. But it presents some curious anomalies. One has not to walk far from the principal streets with fine buildings on either side, shops, offices, clubs and hotels, to reach old shanties which look as if they had been there at the opening of the Rand. Cabs, carriages and automobiles are passing rapidly along the roads (there is no speed limit!), but there is only a single line of slow horse-cars. Instead of a modern sewerage scheme the 'bucket system' is employed. Electric light is furnished by the municipality, but about two thirds of the current has to be purchased. It is only right to state that all these defects are being remedied at a large outlay of money, and the rates are going up at a speed which may give cause for jealousy in certain cities of the northern hemisphere. It is to be remembered that Johannesburg is only eighteen years old and that for four of these years it had to lie fallow, although it practically escaped damage. I must pass over the many interesting features of the social conditions which the society of the place has evolved.

The scientific meetings of the association, begun at Cape Town, ended with the stay in Johannesburg. Many of the papers naturally dealt with problems and matters relating to South Africa; especially was this the case in the chemical and engineering sections during the latter half of the meeting. I shall not attempt to give any *résumé* of the work done; accounts will be found elsewhere. Professor Darwin's presidential address on the evolution of matter was delivered in two halves, one at Cape Town and the other at Johannesburg. It excited great interest for its own sake and also as continuing the connection between the name he bears and the subject which first gave it world-wide fame. The many illustrated evening lectures on a great variety of subjects were a special feature throughout the tour; some of them had been prepared at the cost of much time and money, and, judging by the attendance, were very fully appreciated by those who heard them. The list included the following: 'W. J. Burchell's Discoveries,' by Professor Poulton, and 'Surface Actions of Fluids,' by Professor Vernon Boys, in Cape Town; 'Mountains of the Old World,' by Mr. Douglas Freshfield, and 'Marine Biology,' by Professor W. A. Herdman, at Durban; 'Sleeping Sickness,' by Colonel D. Bruce, and 'The Antarctic Regions,' by Mr. H. D. Ferrar, at Maritzburg; 'Distribution of Power,' by Professor Ayrton, and 'Steel as an Igneous Rock,' by Professor J. O. Arnold, at Johannesburg; 'Fly-borne Diseases, etc.,' by Mr. A. E. Shipley, at Pretoria; 'The Milky Way and the Clouds of Magellan,' by Mr. A. R. Hinks, at Bloemfontein; 'Diamonds,' by Sir W. Crookes, and 'The Bearing of Engineering on Mining,' by Professor J. B. Porter, at Kimberley; 'Experimental Farming,' by Mr. A. D. Hall, at Mafeking; 'Rhodesian Ruins,' by Mr. Randall MacIver, at Bulawayo.

(*To be continued.*)

THE FOUNDATIONS OF GEOMETRY

AN HISTORICAL SKETCH AND A SIMPLE EXAMPLE

BY DR. OSWALD VEBLEN,
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GEOMETRY as a logical system took its first definite form in the mind of Euclid (about 330–275 B.C.); and since the edifice constructed by the grandfather of geometry has justly retained the admiration of all succeeding students, one can perhaps exhibit the modern researches on the same subject in no better way than by contrasting them with some of Euclid's fundamental statements. The propositions which Euclid placed at the foundation of his work have come to us classified under three heads: definitions, postulates, axioms. As examples of the first we may quote (from Todhunter's edition).

1. A point is that which has no parts, or which has no magnitude.
2. A line is length without breadth.
3. The extremities of a line are points.
4. A straight line is that which lies evenly between its extreme points.
5. A superficies is that which has only length and breadth.
7. A plane superficies is that in which, any two points being taken, the straight line between them lies wholly in that superficies.
15. A circle is a plane figure contained by one line, which is called the circumference and is such that all lines drawn from a certain point within the figure to the circumference are equal to one another:
16. And this point is called the center of the circle.

It is evident that in the first of these statements, if 'point' is defined, 'magnitude' or 'parts' is not; in the second, if 'line' is defined, 'length' and 'breadth' are not; and so on. A partial list of the terms undefined in the above definitions would include magnitude, length, breadth, extremities, lie in, lie evenly, equal to. It is in fact a commonplace among teachers and schoolboys that to any one who did not already know what the terms meant, these definitions would be entirely meaningless. Another way of stating the same proposition, and the way upon which modern mathematicians insist, is that in every process of definition there must be at least one term undefined. A thing which is not defined in terms of other things we may call an *element*.

It is also to be observed that in the above list of undefined terms there are at least two classes to be distinguished. The first four terms are nouns and correspond to the notion *element*. The last three are verbs, are conjunctive of elements, and correspond to the notion *relation.* You observe that no formal definition is here made of the words element and relation. I simply try to call up a distinction which I suppose to exist in the reader's mind.

The postulates and axioms of Euclid are so little to be distinguished from each other that in various editions some of the postulates are put among the axioms. The axioms (common notions) were regarded by Euclid's editors and the world at large, if not by Euclid himself, as a list of fundamental truths without granting which no reasoning process is possible. It was nearly as great a heresy in the middle ages to deny Euclid's axioms as to contradict the Bible. Without emphasizing further the historical fact that the axioms were regarded as necessary *a priori* truth, nor the fact that this belief is now largely outgrown, I wish to call attention to a mathematically more important feature. If the axioms are necessarily true, and if they are to be used in proving all things else, they themselves are not capable of demonstration. For mathematical purposes, the axioms are a set of *unproved propositions.* Out of Euclid's definitions and axioms we therefore select for emphasis the presence of

1. Undefined terms $\begin{cases}\text{relations.}\\ \text{elements,}\end{cases}$
2. Undemonstrated propositions.

The postulates of Euclid are as follows. Let it be granted,

1. That a straight line may be drawn from any one point to any other point.
2. That a terminated straight line may be produced to any length in a straight line.
3. And that a circle may be described from any center, at any distance from that center.

His axioms state:

1. Things which are equal to the same thing are equal to one another.
2. If equals be added to equals the wholes are equal.
3. If equals be taken from equals the remainders are equal.
4. If equals be added to unequals the wholes are unequal.
5. If equals be taken from unequals the remainders are unequal.
6. Things which are double oi the same thing are equal to one another.
7. Things which are halves of the same thing are equal to one another.
8. Magnitudes which coincide with one another, that is, which exactly fill the same space, are equal to one another.
9. The whole is greater than its part.
10. Two straight lines can not enclose a space.
11. All right angles are equal to one another.
12. If a straight line meet two straight lines, so as to make the two interior angles on the same side of it taken together less than two right angles, these straight lines, being continually produced, shall at length meet on that side on which are the angles which are less than two right angles.

Modern objections to these axioms are to the effect that most of them are too general to be true, that 2, 3, 4, 9, for example, are not valid in every case where we use the term equality; that the axioms are insufficient in that Euclid uses assumptions not explicitly stated, etc. But our present interest in looking for such faults is not great.

Of all the axioms and postulates, the last is by far the most remarkable and important historically. One is led from internal evidence to believe that Euclid introduced it only after failing to make his proofs without its aid. It is not used before proposition 29, not even in proposition 27 which states that if one line falls on two others

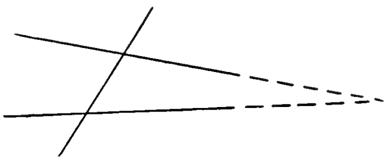

Fig. 1.

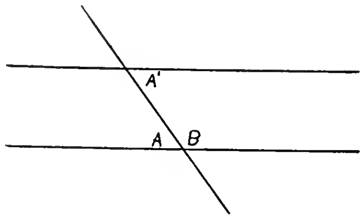

Fig. 2.

so as to make the 'alternate interior angles' (A and A') equal, then the lines are parallel, *i. e.*, do not meet. In proving the converse statement (29), however, he found it necessary to assume that if the sum of the two angles A' and B is less than two right angles the lines will meet when produced far enough. This assumption is axiom 12.

It is perhaps worth while to add that the parallel axiom of which we are speaking may also be stated in the form: 'Through a point, A, in a plane, α, not more than one line can be drawn which does not intersect a line, a, lying in α but not itself passing through A.' The thirty-second proposition, to the effect that an exterior angle of a triangle is equal to the sum of the opposite interior angles, may also be used in place of axiom 12.

The twelfth axiom of Euclid was a stumbling block to many philosophers and mathematicians. While they were ready to grant that they would not be able to reason logically without the other axioms, this one seemed somehow less evident and less fundamental. The natural first attempt was to construct a proof for the axiom so as to give it place as a theorem. Many so-called demonstrations have been offered even up to the present day, but none that have withstood examination. At last, however, the thought came, "what if this axiom were not true? What would become of geometry if axiom 12 were replaced by a new axiom directly in contradiction with it?" It was found that by reasoning based on the reverse of axiom 12 one could involve himself in no contradiction, that, on the contrary, there resulted a new edifice of science which, while different from the old and containing many a strange proposition, yet never denied itself nor violated any of the principles of logic.

These results were obtained first by an Italian Jesuit priest named Saccheri and timidly published in 1733. His work, however, has been known to the modern world only very recently. The non-Euclidean geometry was rediscovered by a Russian, Lobatchewsky (1826), and a Hungarian, Bolyai (1832), though their work also remained unknown to the world at large till 1866 when it fell under the notice of the German mathematician Baltzer. The investigation of the parallel axiom has been continued by Riemann, Beltrami, Helmholtz, Sophus Lie, Cayley, Klein, until it may fairly be said that, ten years ago, this twelfth axiom of Euclid which had at first seemed such a stumbling-block was better understood than any other of his definitions and axioms.

The next attempt after Euclid's to consider geometry as a whole from a purely synthetic point of view was made by a German, Moritz Pasch. His theory, delivered first in a course of lectures in 1873–4, was published in a book called 'Neuere Geometrie' in 1882.

The advance of Pasch beyond Euclid consists essentially in the clear perception of the notions *undefined element* and *unproved proposition*. In other words, he tries to state sharply just what concepts he leaves undefined and does reduce the number of these much below that of the elementary concepts employed by Euclid. He distinguishes between his definitions and axioms. He aims to include in his axioms every assumption that he makes.

His undefined elements are 'point,' 'linear segment,' 'plane surface.' These, according to the axioms, have relations such that a point may be *in* a segment or a surface, a linear segment may be *between* two points (called its end-points). There is also introduced a relation called congruence (geometrical equality) of figures which corresponds to the Euclidean idea of superposition. We will quote only a few of Pasch's axioms, since they can not signify much apart from the propositions developed out of them.

1. Between two points there is always one and only one linear segment.
2. In every linear segment there is a point.

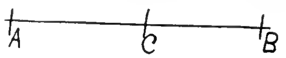

Fig. 3.

3. If a point C lies in a segment AB, then the point A does not lie in thesegment BC.
4. If a point C lies in a segment AB, then so do all the points of the segment AC.
5. If a point C lies in the segment AB, then no point can lie in AB which does not lie in AC or CB.

Out of these assumptions about the relations between points and line segments, together with three other axioms, Pasch deduces the usual propositions about the order in which points lie on a line; the complete line and order itself being defined in terms of the elements and relations mentioned above. He then introduces the plane surface by means of some further axioms, among which are:

1. Every three points are in a plane surface.
2. If a line segment lies between two points of a plane surface there is a plane surface in which lie all points of the given plane surface and also all points of the line segment.
4. If A, B, C are three non-collinear points of a plane surface and any segment DE of the surface has a point in common with one of the segments AB, BC, CA, the line DE has a point in common with one of the other segments or one of the points A, B, C.

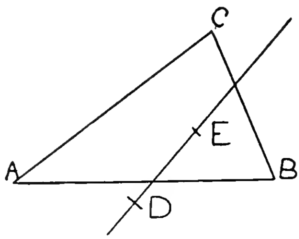

FIG. 4.

This fourth axiom of Pasch is the one that is generally regarded as having required the greatest insight and is most often associated with his name.

A very great improvement over the work of Pasch was made by the Italian mathematician, Peano, who published in 1889 his 'I Principii di Geometria.' The undefined terms of Peano are the elements *point* and *segment* and the relations *lie on* and *congruent to*. The plane segment of Pasch is defined as a certain set of points.

In Italy, at this time, there was beginning a great revival of interest, largely due to the influence of Peano, in the purely logical aspects of mathematics. This has resulted in a large number of investigations not only of the foundations of geometry, but of mathematics in general. The results are mainly expressed in terms of symbolic logic and proceed a long way toward solving the problem to obtain the smallest number of undefined symbols and unproved propositions that will suffice to build up geometry. Besides Peano one needs to mention chiefly Pieri, who has investigated projective geometry and also the possibility of basing elementary geometry on the concepts, *point* and *motion*. Standing aside from the pasigraphical school of Peano, there is Veronese, who has done pioneer work in connection with the axioms of continuity.

In Germany the chief figure at present is D. Hilbert, whose book on 'Foundations of Geometry' (1899) has been translated into several languages, including English. Hilbert's work is the first systematic study that has received widespread attention, and he has therefore been credited with originating a great many ideas that are really due to the Italians. Hilbert's chief contribution to the foundations of geometry is his study of the axioms needed for the proof of particular theorems which he has collected in the latest edition of his book.

The above historical account has no doubt many important sins of omission besides those due to its brevity. But for the purpose of grasping the type of thought involved in these researches further general remarks would probably be less useful than a simple example.

In the academic year 1890–1 Professor C. Segre gave a course of lectures at the University of Turin in which he studied the analytic geometry of n dimensions. A point of n-dimensional space he defined as usual to be a set of $n+1$ homogeneous coordinates $(x_1, x_2, \cdots x_{n+1})$, a line as a set of points satisfying a set of linear equations, etc. To his students, however, he proposed the following problem:

> To define a space Sn not by means of coordinates, but by a series of properties such that the representation with coordinates can be deduced as a consequence.

In other words, he asked for a set of axioms for n-dimensional space. The problem was taken up by one of the students, Gino Fano, now a professor at Turin, and the results published in the *Giornale di Mathematiche*. I wish to reproduce one of the many interesting constructions that Fano obtained and to illustrate by means of it certain concepts that have grown up since then.

Let us take the case of n-dimensional geometry where $n=2$ and proceed for a time as if to build the projective geometry of the plane. Let our undefined elements be called *points* and let us speak of certain *undefined* classes or sets of points which shall be called *lines.* Every one will recognize as valid of projective geometry the following propositions which are our axioms—our unproved propositions.

1. If A and B are points there is one line which contains them both; and
2. There is not more than one such line.
3. Any two lines have in common at least one point.
4. Not all the points are on the same line.

If we stop at this point and try to see how much we can prove on the strength of our assumptions, we are confronted at once by the fact that we can not prove the existence of even a single point. This must therefore be assumed by a further axiom. The assumption of one point is not enough either, but if we assume that there are two points, it follows from 4 that there must be at least three. There need not, however, be more than three, for if we suppose that the points referred to are $A, B, C,$ and that the line AB consists merely of the points A and $B,$ the line BC of the points B and $C,$ and the line CA of the points C and $A,$ then on rereading 1, 2, 3, 4 it is evident that they are all satisfied. Hence in order to get ahead we must assume:

5. In each line there are at least three points.

But this does not postulate the existence of even a single point till we add

6. There is at least one line.

We are now in a position to develop considerably more theory. By 6 and 4 and 1 there must be at least two lines which by 3 meet in a point A. Hence there must be four points at least, (B, C, D, E) which do not lie in the same line. For if D were in the line BC, by 2, the lines AB and AD would be the same, which is contrary to hypothesis.

A set of four points, such as A, B, C, D, of which no three are collinear, when taken together with the lines (called the *sides*) joining the six pairs of points, AB, BC, CD, DA, AC, BD, is called a complete quadrangle. In the diagram below, the vertices of a complete quadrangle are 0, 1, 4, 6. The three additional points 2, 3, 5, in which the sides of the quadrangle intersect, are called the diagonal points.

We have shown our axioms sufficient to establish the existence of a complete quadrangle; are they sufficient to prove the ordinary properties of such a figure? They are not. Axioms 1–6 do not decide whether the three diagonal points, 2, 3, 5, are or are not collinear. In the ordinary geometry, those points are non-collinear and form what is called the diagonal triangle. If, however, we suppose that they are collinear (one may assist one's imagination by means of the dotted line) then on rereading our six postulates they will all be found verified. In order to obtain the usual geometry it is necessary to assume *as an axiom* that the diagonal points of a complete quadrangle are non-collinear.

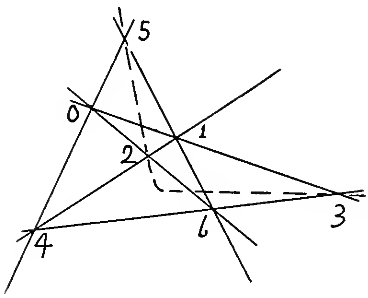

Fig. 5.

What we have just done is a simple case of an 'independence proof.' We have proved that the proposition that the diagonal points of a complete quadrangle are not collinear, is independent of propositions 1, ⋯ 6, that is, it is not a logical consequence of them. Similarly, the non-Euclidean geometry is an independence proof for Euclid's axiom 12. The ideal of students of foundations of geometry is a system of axioms every one of which is independent of all the rest. To attain this ideal it is necessary to construct for each axiom an example in which it is untrue while all the rest are verified.

After seeing the bizarre construction that this process gives rise to, one is tempted to raise the question, how can we be sure that the complete system which we use applies uniquely to the space of our intuition or experience and not also to one of these mathematical dreams? In answering this question we define what is meant by a *categorical* system of axioms.

Returning to our complete quadrangle with collinear diagonal points and observing the numbers placed at its vertices, we may arrange in the same column the numbers of the points that appear together in the same line.

0	1	2	3	4	5	6
1	2	3	4	5	6	0
3	4	5	6	0	1	2

The array thus obtained is known as a 'triadic system' in the seven digits 0, 1, ⋯ 6.

If the undefined element, 'point' of our axioms is any one of the digits 0 ⋯ 6 and 'line' is a column, then the six axioms incompletely describe the triadic system. They describe it completely if we add:

7. There are not more than three points on a line.

I say they describe it completely because we have proved that the axioms are satisfied by seven points arranged as in the triadic system, while from 7 it follows that no other arrangement or number of points is in harmony with the axioms. There is only one kind of thing which satisfies all the axioms 1 ⋯ 7. In other terms, any two systems of objects (for example, the points of the diagram on p. 28, and the triadic system on p. 29) that satisfy axioms 1 ⋯ 8 are reciprocally in a one-to-one correspondence which preserves all the relations of the kind specified in the axioms.

This is what is meant by a categorical system of axioms. Thus in geometry, a categorical system is capable of distinguishing Euclidean space from all essentially different constructions of the mind—and this in spite of the fact that the fundamental elements of geometry are never defined in the ordinary sense of the term definition.

If we have before us a categorical system of axioms, every proposition which can be stated in terms of our fundamental (undefined) symbols either is or is not true of the system of objects satisfying the axioms. In this sense it either is a consequence of the axioms or is in contradiction with them. But if it is a consequence of the axioms, can it be derived from them by a syllogistic process? Perhaps not.

THE CONTENT OF CHINESE EDUCATION[1]

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THAT China is at present in a state of transition along all lines, but especially in educational matters, is patent to all observers. To-day we should distinguish between the old China and the new China. In order to understand the transition now under way we must, of course, consider the forces that have made and characterize the old China. Of these none has had greater influence than the system of literary examinations by means of which civil servants have long been selected. To place this examination system in proper perspective, it is necessary first to notice the characteristics and content of elementary and preparatory education.

It seems, though the records are sufficiently mythical, that as early as 2400 B.C. there were family, town and county schools throughout the empire, but then as now they bore no relation to either the national, provincial or district government. The only national schools have been those for Bannermen, originally on a liberal scale, but now neglected. In various places provincial officers have from time to time opened schools for military, naval or special purposes. Chinese 'colleges,' so-called, are merely advanced schools of grammar, rhetoric and fine writing.

In the primitive period books were few and the youth depended on oral teaching, and the schools in eastern Asia as in western Asia and Greece were ambulatory. Though at a great disadvantage in the matter of libraries as compared with modern students, there were several compensating circumstances which made the ancient schools superior as formers of character, for practical morality was the great object, and intellectual discipline ranked subordinate. In such work the character of the teacher was the prime factor, and the question-and-answer method forced on them by the lack of books excited inquiry and fostered originality. Now only the forms and names of this period remain without the reality.

While there is not and practically never was a school system in China, a method of instruction has prevailed, not only very ancient,

[1] Chinese education of the type described in this article has been abolished by imperial edict of September 2, 1905; but as yet the actual transformation has not progressed far enough to justify the use of the past tense.

but proceeding from and at the same time in great part responsible for those characteristics which mark the Chinese under every variety of physical condition. The cast-iron nature of this method has in several hundred years wasted enough energy for ten millenniums of true education, and this has made China what she is to-day. But the walls are breaking down—such a state can not longer endure.

We purpose to sketch the essentials of this method, and later on to notice the renovation it is experiencing under the influence of western thought and life. Although the Chinese classics have often been reviewed, we shall nevertheless treat the subject matter of Chinese education in some detail, so that we may better appreciate the change that is taking place. Free use of the material afforded by Legge, Williams, Martin, Giles, Smith and Lewis will be made, and our only excuse for taking our own wherever we may find it will be that we shall try to borrow with good judgment.

China's youth are denied that domestic training which is the heritage and boon of western childhood, and so are tremendously handicapped at the very start. After seven or eight years of vegetation a Chinese child is put under the family or clan preceptor or, clad in festal robes, starts for the village school, which is maintained either on a semi-private basis by several families together, or under the patronage of philanthropic gentry, who are liberal enough, but do not always see that the schools are efficiently conducted. The central government bestows imperial honors on benefactors of schools; but having no root in the revenue of the state, Chinese education affords even the most elementary schooling to only a small fraction of the youth of the land.

Improper school-rooms, long hours of study, excessive restraint, frequent absences, but no inspiriting vacations, a severity in the teacher that sometimes reaches barbarism, and utter neglect of physical culture and hygiene, all combine in the predominant type of Chinese school to render the students much below par physically. Nor is the 'infanticide' less intellectual than physical. In all grades the mode of acquisition is the same: imitative and servile. The mental vitality which this ancient people have retained is not by reason of their education, but in spite of it. A real scholar in China is the survivor of hundreds who have failed.

There is no pedagogy in the old China, any one who has learned is deemed competent to teach, for there is only one way, *viz.*, as Dr. A. H. Smith has described, to set each pupil a 'stent' by showing him what sounds to utter and then for each student to bawl out his characters at the top of his voice. When the lesson is 'learned,' that is when the scholar can howl it off exactly as the master has pronounced it, he stands with his back to the teacher and repeats (or 'backs') the lesson in a loud singsong until he reaches the end of his task or of his memory, when his voice suddenly drops from its high key like a June beetle striking a wall. The stimulus of companionship in study is denied, each pupil memorizes, recites and writes in a class by himself, even though many may be engaged on the same passages.

The preceptor is seldom over diligent. Without any personal interest save in the exceptional student, he simply keeps the mill going and is not expected to modify either the curriculum or the method of instruction. There is no variety, no adaptation to pupil, no room for pupil-judgment—only attention cultivated so highly that he can study without diversion amid the greatest din. The scholar must develop 'phonographic' abilities of memory; if not, there is no remedy except the rod. Recent native schools along more modern lines have swung to the other extreme and are entirely too lax, and there have been many instances in which the student body has presumed to run the school. The aversion to the old-style severity of the native teacher has been a primary cause of the frequent rebellions in foreign schools in China when a stand for faculty-power in proper discipline has had to be firmly though kindly taken.

Sons of shopkeepers and farmers and others who do not expect to enter the lists for literary honors, but merely to acquire a moderate proficiency in the native language, are put through a three- or four-year course in six elementary classics which the aspirant for a degree usually skips, beginning at once with the 'Four Books,' which may be studied also by the more clever of the lower class. Thus the literary graduate who turns pedagogue in an elementary school has himself probably never traversed as a student the texts he is to teach, though his knowledge of the superior classics renders this superfluous, except in the point of appreciating the scholars' difficulties.

Owing to the ideographic nature of the language, one aspect of Chinese education is practically beyond the ken of western peoples. Each character requires a distinct memory effort, and the recognition of its form and name is made to come at one stage of instruction, its meaning much later on.

Dr. Smith compares the aggregate bulk of the classics which must be accurately engraved on the child's memory with the Old Testament. No other writings have been ground into the memories of so many of earth's millions; and the precepts they contain have had such a determining effect in producing Chinese character that, under the risk of being tiresome, we shall pause to glance at their content.

1. *The Trimetrical Classic*, a mosaic with three characters in each clause, universally employed unchanged for eight and a half centuries. Its 1,068 words, or 534 different characters, deal with the nature of man and of numbers, necessity and modes of education, filial and fraternal duties, the names of the heavenly bodies, the three great powers, four seasons, four directions, five ele-

ments, five cardinal virtues, six grains, six domestic animals, seven passions, eight kinds of music, nine degrees of kindred, and the ten moral and social duties, followed by a summary of future studies and a catalogue of dynasties up to 1644, when the present dynasty began, the latter not being thought a fit subject for instruction, as if a class in English history should halt at the accession of the House of Hanover!

2. *A Century of Surnames*, 454 clan names to be memorized.

3. *Millennary Classic*, 1,000 distinct characters, written A.D. 550 as a connected ode, possessing rhyme and rhythm, but no more poetry than the multiplication table; in fact, its characters are used as ordinals to designate the successive rows of stalls in the triennial examination halls. In subject matter it is similar to the 'Trimetrical Classic,' but more discursive.

4. The *Odes for Children*, 136 lines in rhymed pentameters, containing a brief description and praise of literary life and allusions to the changes of the seasons and the beauties of nature.

5. *Canons of Filial Duty*, a tract of 1,903 characters, representing a conversation between Confucius and a disciple concerning the chief virtue inculcated by his school.

6. *The Juvenile Instructor*, which is said to exhibit better than the works of later scholars the Chinese ideas in all ages on principles of education, rules of conduct, etc.

A host of commentaries (over fifty on 'The Juvenile Instructor' alone) more copious than the texts themselves are employed to illumine and amplify the string of ideas presented as 'primer-stimuli' to the youthful mind.

The task of memorizing the contents of these six *elementary* school books, which have had such a formative influence on the large proportion of students who go no further, is somewhat relieved by exercises in penmanship. After two or three years spent thus, explanations are in order, and the student is introduced to the various commentaries. Such a course of study surely stunts the genius and drills the faculties into a slavish adherence to venerated usage and dictation.

Though followed chiefly by those destined to practical lives, this curriculum far from fits them for ordinary duties. Formal letter-writing and even elementary arithmetic are not taught in the Chinese school of the old type, and proficiency in either is obtained only by a sort of apprenticeship or by private instruction. No knowledge of business Chinese is imparted, so that the majority of those who fail to carry their studies high enough for degrees are not prepared for practical life.

The course of instruction for those who are likely to try for literary honors consists of three stages, each of which embraces two leading subjects. The 'Trimetrical Classic' may have been taken as preparatory, though not necessarily.

I. In the first stage the aim is to get words at the tongue's end and characters at the pen's point, by memorizing the canonical classics and writing an infinitude of characters as a mere manual exercise—a system sure to prevent precocity and preclude originality. The whole of the 'Four Books' and often a good part of the 'Five Classics,' all in a dead language, are encompassed by pure memory before any explanation of their meaning is given. 'The Four Books' require two years even for a clever scholar, while to include the 'Five Classics' extends the cheerless task to four or five years even for the cleverest, though a total of seven would perhaps strike the average. During this period of mental daze, the scholar is 'a pig in the woods'; his entrance on study is 'lifting the darkness,' and to teach a beginner is 'to instruct darkness.' Such phrases depict reality. The method of instruction and the characteristics of the teacher are the same as have already been noted.

The texts which are thus swallowed whole to await a deferred digestion are forever taken as models of correct composition and with their commentaries are regarded as embracing about all there is to know. 'The Four Books' contain digests of the moralizings of Confucius (551–478 B.C.) as gathered by his disciples, and consist of 'The Great Learning,' 'The Doctrine of the Mean,' 'Confucian Analects' and the 'Words of Mencius' (371–288 B.C.).

Confucius, the Aristotle of Asia, produced as a self-confessed 'transmitter and not a maker' a 'system of ethics or of anthropology' in which man, his relations to family, society, the state and heaven are fully discussed and the attributes and conduct of the 'Princely Man' elaborated in detail. The leading features of the Confucian doctrine are 'subordination to superiors and kind upright dealing with our fellow men.' The foundations of political morality are found in private rectitude. Though containing some exceptionable dogmas, these writings as compared with those of Grecian and Roman sages are good in their general tendency, and in adaptation to the life of the time eminently practical. The defects and errors of Confucianism are, briefly stated, 'the production of a character which is essentially mundane in spirit, the development of the passive rather than of the active virtues, the suppression of individuality, and the evil effects of neglecting the study of nature.'

The 'Great Learning,' *Ta Hsüeh* (or 'Learning for Adults,' 2,000 words), was, prior to Chü Hsi in the eleventh century, a section of the 'Book of Rites.' It discusses the duties and privileges of the princely or superior man, and has been styled a 'system of social perfectionating' or 'politico-ethical treatise.' Its authorship is unknown, but usually the first of its eleven chapters is attributed to Confucius, while the rest is due to the compilers, expanders and annotators through whose hands it has come. The portion supposed to have come directly from the master himself contains the following well-known climax:

> The ancients, desiring to manifest great virtue throughout the empire, began with good government in their own states. For this, it was necessary first to order aright their own families, which in turn was preceded by culti-

vation of their own selves, and that again by rectification of the heart, following upon sincerity of purpose which comes from extension of knowledge, this last being derived from due investigation of objective existences.

The *Chung Yung*, or 'Doctrine of the Mean' (or as Julien renders it 'L'Invariable Milieu,' or Williams, 'The Just Medium'), was also formerly a part of the 'Book of Rites,' and was compiled about 388 B.C. by K'ung Chi, the grandson of Confucius. Although in some respects the most elaborate treatise in the series (33 chapters), it is merely an enlargement upon certain general principles of the writer's grandfather concerning the motives and conduct of an ideal perfect man who 'without deflection or bias' pursues 'a course which never varies in direction.' Though in general rather monotonous there are some sprightly passages, for example, the following:

The princely man enters into no situation where he is not himself. If in a high position he holds no contempt for those below him; if in an inferior station, he uses no mean arts to curry favor with his superiors. He corrects himself and blames not others; never dissatisfied, he murmurs not at Heaven and feels no resentment toward man. Hence, the superior or princely man dwells at ease, entirely awaiting the will of Heaven.

Mankind is divided into three classes: (1) *shing*, or sages; (2) *hien*, or worthies; (3) *yu*, or worthless.

Men of the highest order, as sages, worthies, philanthropists, and heroes, are good without instruction; men of the middle class, such as farmers, physicians, astrologers, soldiers, etc., are good after instruction; while those of the lowest, as actors, pettifoggers, slaves, swindlers, etc., are bad in spite of instruction.

Sincerity is described as "the origin or consummation of all things; without it, there would be nothing. It is benevolence by which a man's self is perfected, and knowledge by which he perfects others." In another place we read 'one sincere wish would move heaven and earth.' The description which K'ung Chi has given of a true sage was probably intended to elevate the character of his grandfather to this height—a standard of excellence so high as to be unattainable by unaided human nature.

It is only the sage who possesses that clear discrimination and profound intelligence which fit him for a high station; who possesses that enlarged liberality and mild benignity which fit him to bear with others; who manifests that firmness and magnanimity that enable him to hold fast good principles; who is actuated by that benevolence, justice, propriety and knowledge which command reverence; and whose thorough acquaintance with polite learning and good principles qualifies him rightly to discriminate. Therefore his fame overflows the Middle Kingdom, and reaches the barbarians of north and south. Wherever ships and wagons can go, or the strength of man can penetrate; wherever there is heaven above and the earth beneath; wherever the sun and moon shine, or frosts and dews fall,—all who have blood and breath honor and love him. Wherefore it may be said that he is a perfect and holy man,—the peer of God.

The *Lun Yu*, or Analects of Confucius, is a record of the words and actions of the Sage compiled by the collective body of his first apostles and abounding in sententious dialogues and monologues. It is to Confucius what Boswell's work is to Johnson. From it comes all we really know about the great moralist, contemporary with Ezra, whose mission was to teach duty towards one's fellowmen. The Analects are the pattern of Chinese wisdom literature.

The last of the 'Four Books,' bearing the name of Mencius (371–288 B.C.), is as large as the other three combined, and constitutes, according to some critics, the most vital reality in all Chinese literature. Its seven sections record the sayings and doings of a man to whose genius and devotion is due the triumph of Confucianism. Coming to maturity upward of a century after the death of Confucius, he studied under the latter's grandson, K'ung Chi, and though of course profiting greatly by the example and stimulus of the earlier sage, in most respects he displayed an originality, resoluteness and breadth superior to Confucius, and must be ranked as one of the greatest men Asia has produced. He served various native princes as minister in their several states and spent the last twenty years of his life in teaching and in completing the work which has been such a power in the land. Living at a time when feudal princes were squabbling over rival systems of federation and imperialism, he strove to inculcate the gentle virtues of the golden age. While his criterion was that of Confucius, his teachings were more practical and dealt rather with man's well-being from the view-point of political economy. His assertion of the respective duties and prerogatives of subject and ruler is said to be prior to that of any western writer, and in the Middle Kingdom has always been an incentive and guide in defending the rights of the people against the injustice of rulers, and an encourager to those who have governed justly. His dialogues with the great personages of his time abound with irony and ridicule against vice and oppression. Witness the following example, cited by Williams:

> The king of Wei, one of the turbulent princes of the time, complained to Mencius how ill he succeeded in making his people happy and his kingdom flourishing. "Prince," said the philosopher, "you love war; permit me to draw a comparison from thence; two armies face each other; the charge is sounded, the battle begins, one of the parties is conquered; half of its soldiers have fled a hundred paces, the other half has stopped at fifty. Will the latter have any right to mock at those who have fled further than themselves?"
>
> "No," said the king; "they have equally taken flight, and the same disgrace belongs to both."
>
> "Prince," says Mencius quickly, "cease then to boast of your efforts as greater than your neighbors'. You have all deserved the same reproach, and not one has a right to take credit more than another." Pursuing then his bitter interrogations, he asked, "Is there a difference, O king! between killing a man with a club or with a sword?" "No," said the prince. "Between him who kills with the sword, or destroys by an inhuman tyranny?" "No," again replied the prince.
>
> "Well," said Mencius, "your kitchens are burdened with food, your sheds are full of horses, while your subjects, with emaciated faces, are worn with misery, or die of hunger in the middle of the fields or in the deserts. What

is this but breeding animals to prey on them? And what is the difference between destroying them by the sword or by unfeeling conduct? If we detest these savage animals which mutually tear and devour each other, how much more should we abhor a prince who, instead of being a father to his people, does not hesitate to rear animals to destroy them. What kind of a father to his people is he who treats his children so unfeelingly, and has less care of them than of the wild beasts he provides for?"

The will of the people is always referred to as the supreme power of the state, and Mencius warns princes that they must both please and benefit their people, observing that "if the country is not subdued in heart there will be no such thing as governing it. . . . He who gains the hearts of the people secures the throne, and he who loses the people's hearts loses the throne. Good laws," he further remarks, "are not as effective as winning the people by good instruction."

II. After accurately memorizing the 'Four Books,' having relieved the drudgery with exercises in writing, the student generally enters on the second stage of his education, which, however, is unfortunately in many cases postponed until the 'Five Classics' have also been engraved on memory's tablet. In this second stage, the scholar is initiated into an understanding and translation into the vernacular of the sacred books previously committed. But the light is rather sparingly admitted even then. A simple character here and there is explained and perhaps after a year or two the teacher explains entire sentences. Judiciously employed, this does for the Chinese what translation into and out of the dead languages of the west does for us. Yet, as Dr. Martin claims, this second stage is made as much too easy as the first course is too difficult. Instead of requiring a lad, dictionary in hand, to quarry out the meaning of his author, the teacher reads the lesson, and demands simply a faithful reproduction; a feat of sheer memory again. Simultaneously with this training in exposition or translation the student begins to practise composition. But here again the lack of inflection and the predominence of collocation, the 'polarity' in which is determined by previous usage, make composition in the Chinese language difficult and throw the burden on the imitative faculty—a strong trait as evidenced at present among all classes of the people.

Although the whole course is designed with the civil service examinations in view, it is pursued without variation by those who are not looking toward office-holding. Yet at the close of this second stage, the boy who expects to enter civil service begins to prepare rather more specifically for the examinations. He is perhaps fourteen, and for two years or more he widens his reading, 'opens his pen,' and makes essays for his master's criticism, and may then be ready to enter the lists for the first degree.

III. In the third stage of the Chinese scholar's career, composition becomes the main object, reading being wholly subordinate. According to Dr. Martin, the primary step in Chinese composition is yoking double characters followed by practise in reduplicating such binary compounds to form parallels, an idea which runs through the whole of Chinese literature. Detailed symmetry is a chief characteristic of Chinese composition as practised by old methods. Chiefly artificial forms of verse and an even more artificial form of prose are acquired and mark the climax of the whole course. The reading includes rhetorical models and sundry anthologies. History is studied, but only in compends, not to gain wisdom, but merely to embellish classic essays with a profusion of historical allusions. Knowledge and mental discipline are discounted and style is at a premium. In such a system progressive knowledge is alien and education with such a goal is necessarily superficial.

The 'Five Classics' follow the 'Four Books,' and we shall briefly note their content.

If not the oldest, certainly the most venerated member of this Pentateuch is the *I Ching,* or 'Book of Changes,' whose diagrams date back 2800 B.C., the text to 1150 B.C., and the Confucian commentary thereon to 500 B.C. It ranks chief in the canon of Taoism and was spared from the flames of the Tyrant of Ch'in to which all the other writings of Confucius and his disciples were consigned in 213 B.C., only to be rehabilitated from the living memories of devout literati. The accredited author of the text, Weng Wang, was the virtual founder of the great Chou dynasty (B.C. 1122–249) and the contemporary of Pythagoras. It is a fanciful system of philosophy based on a set of trigrams, each of which represents some power in nature whose combinations are developed in sixty-four short essays, enigmatically and symbolically expressed, on moral, social and political themes, as well as on the more lofty and subtile subject of the origin and destiny of cosmos. The whole universe, in broad and in detail, is ascribed to the interactions of two great male and female elements, the *Yin* and the *Yang,* which in turn proceed from *T'ai Chi,* or the first great cause. The text is followed by commentaries called the 'Ten Wings,' generally ascribed to Confucius, whose extravagant admiration of the *I* led him to declare that were a hundred years added to his life, he would give fifty of them to the study of the *I* so that he might come to be without faults. But the work appears to be little more than a lot of enigmatical gibberish intended for the prognostication of good and bad fortune. From it charlatans of all sorts have drawn their supplies. The following is a specimen of the text and the accompanying wing (Legge's translation):

TEXT. ䷉ This suggests the idea of one treading on the tail of a tiger, which does not bite him. There will be progress and success.

1. The first line, undivided, shows its subject treading his accustomed path. If he goes forward, there will be no error.

2. The second line, undivided, shows its subject treading the path that is level and easy;—a quiet and solitary man, to whom, if he be firm and correct, there will be good fortune.

3. The third line, divided, shows a one-eyed man who thinks he can see; a lame man who thinks he can walk; one who treads on the tail of a tiger and is bitten. All this indicates ill-fortune. We have a mere bravo acting the part of a great ruler.

4. The fourth line, undivided, shows its subject treading on the tail of a tiger. He becomes full of apprehensive caution, and in the end there will be good fortune.

5. The fifth line, undivided, shows the resolute tread of its subject. Though he be firm and correct, there will be peril.

6. The sixth line, undivided, tells us to look at the whole course that is trodden, and examine the presage which that gives. If it be complete and without failure, there will be great good fortune.

WING. In this hexagram we have the symbol of weakness treading on that of strength.

The lower trigram indicates pleasure and satisfaction, and responds to the upper indicating strength. Hence it is said, 'He treads on the tail of a tiger which does not bite him; there will be progress and success.'

The fifth line is strong, in the center, and in its correct place. Its subject occupies the God-given position, and falls into no distress or failure;—his action will be brilliant.

The apparent meaninglessness thus exhibited is admitted by Chinese scholars, who, however, tenaciously believe that valuable lessons await those with the wit to understand them. Some fourteen hundred and fifty treatises on the *I*, embracing memoirs, digests, expositions, etc., are enumerated in the Imperial Catalogue, and the continued influence of such a work well illustrates the Chinese propensity for rules and methods along with their utter neglect of empirical research and the observational study of nature.

The *Shu Ching*, or 'Book of History,' goes further back in its records (2357–627 B.C.) than any of the other classics, though as a collected whole it seems to be due to the editorial effort of Confucius (551–478 B.C.). Only fifty-nine of the original hundred books are extant. They embody imperial ordinances and decrees, plans proposed by statesmen as guides for the sovereign, proclamations to the people, vows taken by the monarchs when engaging in battle, and mandates, announcements, speeches, etc., issued to the ministers of state. Much of the matter is presented in the form of dialogues between and about the kings and ministers of the various dynasties. These contain many of the best maxims of good government, both for rulers and ruled, which antiquity has bequeathed in any country. Many of the personages are legendary and some of their exploits fabulous. In the eyes of the Chinese who have not yet been affected by modern ideas, the *Shu Ching* contains the seeds of all things valuable. Williams says it has at once been 'the foundation of their political system, their history, and their religious rites, the basis of their tactics, music and astronomy.'

The *Shih Ching*, or 'Book of Odes,' is another work which Confucius preserved for posterity. It is a collection of rhymed ballads whose ages run from probably 1719 B.C. to 585 B.C. They are 305 in number though they appear to have been reduced by mishaps and editorial selection from as many as 3,000. Giles thus exhibits their arrangement:

(*a*) Ballads commonly sung by the people in the various feudal states and forwarded periodically by the nobles to their suzerain, the Son of Heaven. The ballads were then submitted to the Imperial Musicians, who were able to judge from the nature of such compositions what would be the manners and the customs prevailing in each state, and to advise the suzerain accordingly as to the good or evil administration of each of his vassal rulers.
(*b*) Odes sung at ordinary entertainments given by the suzerain.
(*c*) Odes sung on grand occasions when the feudal nobles were gathered together.
(*d*) Panegyrics and sacrificial odes.

Confucius regarded a man unacquainted with the 'Book of Odes' as unfit for intercourse with intellectual men. According to him the design of all may be expressed in the one sentence, 'Have no depraved thoughts.'

Early commentators ignoring the natural beauties of these poems have saddled these ditties with weighty moral and political allegories. This may have served to preserve a work which would otherwise have been deemed too trivial. The native literature, illustrative, critical, and philological dealing with the 'Book of Odes' is not as large as that on the 'Book of Changes,' but Chinese scholars know it by heart, and each separate verse has been so searchingly examined that exegesis can go no further. The fifty-five commentaries mentioned by Legge in his translation increase our opinion of Chinese scholarship when we remember its isolation from the literature of other lands.

A nation's ballads have often been regarded as a more important factor in the life of the people than its laws, and the insight which the 'Book of Odes' gives into the customs and feelings of ancient China is its chief merit. While these poems lack the grandeur of the Greek and Latin productions, they are fortunately free from the looseness that too often detracts from the latter. As the 305 odes are usually committed to memory before coming to the examination hall, all poetical efforts of Chinese scholars have been practically molded by them.

Though in some of the odes women are roughly handled and perhaps the position of women to-day is in part due to their influence, the fairer side also appears, and contrasts in female character like those portrayed by King Solomon in the same age are presented. Witness the following specimens, the first as translated by Giles and the second by Williams.

(1) A clever man builds a city,
A clever woman lays one low;
With all her qualifications, that clever woman
Is but an ill-omened bird.
A woman with a long tongue
Is a flight of steps leading to calamity;
For disorder does not come from heaven,
But is brought about by women.
Among those who can not be trained or taught
Are women and eunuchs.

(2) Maiden fair, so sweet, retiring,
At the tryst I wait for thee;
Still I pause in doubt, inquiring
Why thou triflest thus with me.

Ah! the maid so coy, so handsome,
Pledged she with a rosy reed;
Than the reed is she more winsome.
Love with beauty hard must plead!

In the meadows sought we flowers,
These she gave me—beauteous, rare:
Far above the gift there towers
The dear giver—lovelier, fair!

The eighth ode in Book III., called *Hiung Chi,* or 'Cock Pheasant,' contains a wife's lament on her husband's absence. Legge's version is:

Away the startled pheasant flies,
With lazy movement of his wings;
Borne was my heart's lord from my eyes—
What pain the separation brings!

The pheasant, though no more in view,
His cry below, above, forth sends.
Alas! my princely lord, 'tis you,—
Your absence, that my bosom rends.

At sun and moon I sit and gaze,
In converse with my troubled heart.
Far, far from me my husband stays!
When will he come to heal its smart?

Ye princely men, who with him mate,
Say, mark ye not his virtuous way?
His rule is, covet naught, none hate:
How can his steps from goodness stray?

The *Li Chi,* or 'Book of Rites,' is a collection (*cir* B.C. 135) of rules of personal conduct in private and public life, every movement in official or social life being controlled by it. There are two other similar works of considerably greater antiquity, but this one alone is included in the classic canon of examination texts. The Board of Rites, an imperial department, concerns itself largely in expounding and enforcing the *Li Chi*. Its other principal duty is to manage the workings of the examination system.[2]

The fifth classic, *Chun Chiu,* or 'Spring and Autumn Annals,' is generally ascribed to Confucius himself, though not surely. It is a very brief record of the chief events between 722 and 484 B.C. in Lu, the native state of the sage. It seems to have been intended as a continuation of the 'Book of History,' but critics have shown that it is not only biased and unjust to the facts, but wilfully misleads. With it as it now exists there is associated the amplifying and vivifying commentary of Tso, a follower of Confucius, and without this, these annals, in spite of the fame of their reputed author, would not have merited and might not have received the attention that Chinese scholars have accorded them.

With these nine books the Chinese student saturates his mind in preparation for the examinations, and from them derives his training in sociology, ethics, political and other maxims, cosmogony, history, and historical romancing, poetry, and, by no means least, in manners. As Mr. R. E. Lewis has expressed it: "Though the curriculum is largely religious in its control, yet it provides practically no teaching of Theism. Though it is the permanent support of absolutism, yet it guarantees large liberties to the populace."

The classics which have been noted are by no means the whole of Chinese literature with which the aspirant for literary honors must be familiar. In order that his interpretation may be accurate as well as orthodox, he must consult some 1,120 commentaries on the 'Five Classics' and 170 on the 'Four Books.' For the scholar who has secured his first and second degrees there is the vast literature, over 3,000 volumes, of poetry, drama, romance and encyclopedic works covering with fluctuations in volume the stretch from 200 B.C. to the present time, though of course the later works are at a discount as compared with the more ancient. Professor Giles, of Cambridge University, has given an excellent review in his recent 'Chinese Literature,' as has also Dr. Martin in his 'Lore of Cathay.'

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[2] Both the examination system and the Board of Rites were abolished by imperial edicts of September and October, 1905.

THE GEOLOGIC SURVEY OF ALASKA[1]

By ALFRED H. BROOKS
U. S. GEOLOGICAL SURVEY

A DECADE[2] ago the United States Geological Survey began its work in Alaska by sending a party of only three men to the territory, whereas in the past summer twelve parties, with an aggregate membership of fifty odd men, were there engaged in geologic surveys. Even this rapid expansion is hardly commensurate with the size of the territory and the importance of the mineral resources, the development of which the geologic investigations aim to aid. Alaska's 600,000 square miles are much spread out, stretching to a width of 2,400[3] miles and to a north and south length of 1,100 miles. Were this vast area, which is equal to two and a half times that of Texas, the cold, barren waste so often pictured it would be of small practical import as to when it should be surveyed. But Alaska has large and constantly growing mining interests, and it is the demand of these which has influenced congress to increase the appropriation for geologic surveys from $5,000 in 1895 to $80,000 in 1905.

Even the present appropriation is less than one per cent. of the annual gold production, which has increased from $1,866,645 in 1895 to $9,300,000 in 1904, and is far from having reached its maximum. Nor does the gold production tell the whole story; the value of the copper and silver annually mined now exceeds half a million dollars, and the output of the former is rapidly increasing. There is in Alaska also some coal mining, though this industry has not yet attained its rightful importance. The territory contains some very valuable bituminous coal fields. Prospective mineral wealth also lies in Alaska's tin ores, oil fields and gypsum beds, which have all been sufficiently exploited to indicate their probable commercial importance. The time will come when iron and zinc ores are mined in Alaska, and its immense granite areas will yield building stone to the Pacific coast.

Applied geology touches the activities of mankind at many places, but primarily, of course, in the vocation of mining. It is on the basis of geologic knowledge that soils must be classified, and this, in turn, together with the topography, determines the distribution of animal and vegetable life. In the Alaskan work of the geological survey,

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[1] Published by permission of the Director U. S. Geological Survey.

[2] It will be shown below that members of the Geological Survey were sent to Alaska before 1895, but these were either detailed to other government bureaus, or were attached to private expeditions.

[3] This is about the distance from Savannah to Los Angeles.

practically only the needs of the miner have to be considered. The agricultural and allied interests of the territory are being investigated by other governmental bureaus.

The attitude of the public towards the science of applied geology has so materially changed during the last decade that its practical value is now generally recognized, though a few still remain skeptical as to the commercial importance of the results. This attitude exists partly because geology (not being an exact science) has often been brought into disrepute by dilettantism, if not downright charlatanism. Among technicians, however, it has become generally accepted that with the increase of geologic knowledge of a given region comes a decrease of the element of chance in the discovery of ore bodies. Intelligent prospecting should and can be based upon scientific principles, for a properly executed geologic map will define the areas within which there is a probability of finding a given kind of mineral deposit. The veriest tyro need hardly be told not to seek coal in a granite, nor would he ordinarily prospect for gold in a region of coal-bearing rocks. The geologist carries this classification of the rocks still farther, and may thereby prophesy the occurrence of ore deposits in a region which he has mapped. The actual discovery of ore is no part of the work of the geologist; this demands detailed examinations and often excavation, such as only individual property-owners can make. This point is emphasized because, even among the well-informed, the question is often raised why the geologist does not more often discover mineral deposits. Lack of appreciation of the relation of applied geology to mining is traceable in part to the stories current of the bonanzas discovered by an accident to a mule, the luck of a tenderfoot or the appetite of birds, which are in the popular mind so interpreted as to throw discredit upon geologic science.

The intelligent prospector has learned that even at best his chance of success is small; but is much increased by a knowledge of the geology of a region he intends to explore. With a better understanding of the laws which govern the occurrence, origin and distribution of mineral deposits the old-fashioned, picturesque haphazard prospector, to whom it must be admitted we owe the discovery of most of our mineral wealth, will disappear, and the technician will take his place. This is probably the last field where the specialist will crowd out the man of purely practical training; but it is a substitution bound to take place in time.

A geologic survey has two objects: first, the increase of scientific knowledge, and, second, the application of this knowledge to the mining industry. The purely scientific investigations include many subdivisions and ramifications that can not here be considered, but it will be evident, even to the layman, that, while any part of the earth's surface remains geologically unmapped, there will be a hiatus in our knowledge, which may prevent broad generalizations.

In Alaska special attention has been given to the second field of activity, namely, the application of geology to the needs of the miner. This is in part the influence of the growth of economic work in both state and federal surveys during the last decade, but more specially because the appropriation is specifically made for the investigation of the mineral resources of Alaska. With this end in view, a score of publications dealing with the occurrence and distribution of the mineral deposits of the territory have been issued. It has been the policy to make public the results attained while yet the investigation is in progress, in the belief that even an incomplete knowledge of the geology would be of value to the miner. With this end in view, bulletins treating of the occurrence of coal, petroleum, tin and copper have been issued, as well as many which are devoted to the gold deposits. These preliminary reports have found favor with the mining public because of their timely appearance, and have forestalled criticism of delay in issuing the more elaborate treatises.

The danger in issuing such reports is that the less intelligent miner may accept tentative statements as final conclusions, and this may lead to losses. It is impossible to escape this danger entirely, for to avoid all opinions which are not definitely established by the facts in hand, shears a geologic report of much of its usefulness to the practical man, who wants the expert who has visited the field to prophesy what the conditions of occurrence of the ore bodies are likely to be.

While applied geology has been kept constantly to the front in the Alaskan investigations, the study of the broader problems, be they stratigraphic, physiographic or paleontologic, has by no means been lost sight of. The purpose of every geologist sent to the north has been twofold: first, the gathering of information which will directly advance the mining interests, and, secondly, the study of the purely geologic problems. It has been the policy to defer the publication of purely scientific results until a larger number of facts have been accumulated, and the theoretic discussion can be supported by the knowledge of a wider field. Thus only the salient outline of the stratigraphic succession has been put in print, but meanwhile a number of specialists have been carrying on paleontologic and stratigraphic studies to determine definitely certain geologic horizons to which all future work can be referred. In the same way, though a large petrographic collection has been amassed, its detailed study has been deferred until a broader knowledge of the field relations can be secured. Other branches of geologic science have been treated in a similar way. It is hoped that in this way a basal knowledge of the larger problems will be available in a few years, on which to found detailed studies with more assurance.

A geologic map can not be constructed without an adequate base map. As in the west there were practically no adequate and systematic topographic surveys of the interior before the organization of state and federal geologic bureaus, it naturally fell to these organizations to construct base maps for their work. The same holds true of Alaska, where the conditions have been even less favorable because of the many large areas which have been practically unexplored. It is no exaggeration to state that, at the inception of this work, there was not a single area, large or small, except at the actual coast line, of which there was a map of even approximate accuracy. A few explorations had, to be sure, been made; but the resulting maps were absolutely worthless for geologic mapping and of little use for anything else. Thus the survey of one of the largest rivers of the territory proved to be thirty to forty miles out in location, near-by mountains, whose altitude had been indicated at seventeen to nineteen thousand feet, proved to be less than fifteen thousand feet in altitude. It is evident, then, that an investigation of the mineral wealth had to be preceded or accompanied by accurate geographic surveys. Maps were needed not only by the geologist, but also by the prospector and miner. The mining interests demanded that watercourses should be surveyed and passes and watersheds explored. During the Klondike excitement of 1898 there were at least 10,000 people in Alaska who were attempting to follow unexplored routes and to navigate unmapped rivers. It is no exaggeration to state that the cost of these fruitless efforts aggregated several million dollars, many times the cost of a survey of the entire territory. In view of these conditions, much of the money, therefore, appropriated for the investigation of Alaska's mineral wealth was necessarily used for explorations and for topographic surveys.

Older Explorations and Surveys.

It will be well to review briefly the progress of Alaskan explorations previous to the time when the Geological Survey entered this field. When, in 1867, Russia ceded all her North American possessions to the United States, so little was known of this province that it is hard to understand what was the basis for the purchase price of $7,200,000. To Russia Alaska had been a field for private speculation rather than an integral part of the empire. First, ravaged by the itinerant and half savage fur trader, and then, for two thirds of a century, in the complete control of an incorporated company, the territory was probably not regarded as a valuable asset by the Czar and his advisers. To be sure, during the last two decades of the Russian dominion, naval officers had been been sent from St. Petersburg to govern the colony, and a semblance of imperial authority was thereby kept up; but this control was limited to but a fraction of the coast line and to the lower courses of some of the larger rivers. The Russian posts were all stockaded, and the powers of the governor were practically limited to the range of his crude artillery. The Russians made some coastal surveys, a few inland explorations, and one abortive attempt to find gold, and this was as far as they went in the study of the resources of their distant colony.

William H. Dall and his associates of the Western Union Telegraph expeditions, in 1865–7, did much toward gaining a knowledge of the vast interior. The navigators of various nationalities, who had explored and charted the coast line, had gathered fragmentary data of the natural history and geology, and these, together with the specimens collected by them, had found their way to European museums, where they were examined and described by scientists. One of these, by name Carl Greywingk, a German, with infinite pains and thoroughness, compiled all the notes on the geology and geography of Alaska, then known as Russian America. He went so far as to publish a geologic map of a part of the territory—a very remarkable piece of work, considering the fragmentary character of his data.

It appears that the people of the United States were even more indifferent to Alaska than the government at St. Petersburg. There had been strong opposition to its acquisition, both by those adverse to any territorial expansion, and also by a much larger number, who believed that we were purchasing a barren waste of ice and snow, whose only resource was furs. After the treaty had been signed and military occupation had been taken, the general opinion seemed to be, even among the annexationists, that we had fulfilled our duties toward the new possession. A policy of neglect of this northern province has been consistently followed almost to the present day. It was sixteen years after its annexation that Alaska was given a civil government, it was thirty-three years before it was given a complete civil code, and over a quarter of a century elapsed before systematic steps were taken toward investigating its resources.

In the meantime, individual enterprise did much toward opening the province to civilization. A strong corporation had succeeded to the interests of the old Russian American Fur Company, and, though it inherited most of the prejudices of its predecessors against the introduction of any new enterprises, nevertheless its agents, bent only on the acquisition of furs, did not a little to find new fields for the prospector.

The real exploration began with the advent of the restless gold seeker. The search for gold on the west coast of our continent, begun by the discovery of the California placers in 1848, gradually moved northward into British Columbia, and by 1870 had reached the Cassiar district, close to the Yukon watershed. It was the men trained in the placer fields of British Columbia who first prospected in Alaska, and who by 1880 were mining in the Juneau region, and a few years later in the Yukon basin itself. These facts are here set forth because it was the prospector who made almost the first observations on the geology of the interior.

There were, to be sure, a number of exploring expeditions which, considering the resources at their command, had achieved important results, but they were geographic rather than geologic. Thus Frederick Schwatka, U.S.A., following the route blazed out by early prospectors, crossed the Chilkoot Pass in 1883 and made his way down stream to the mouth of the Yukon. In 1885 H. T. Allen, U.S.A., explored the Copper, Tanana and Koyukuk rivers, while about the same time G. M. Stoney, U.S.N., and J. C. Cantwell, U.S.R.C.S., led expeditions which penetrated the Arctic watershed of Alaska. The Canadian geologists, George M. Dawson and R. G. McConnell, had meanwhile explored the Canadian part of the Yukon basin. In 1890 I. C. Russell, of the Geological Survey, reconnoitered the geology of the Yukon, while attached to a coast survey party whose aim was to determine the position of the international boundary. Schwatka made a second trip into the interior in 1891 and this time was fortunately accompanied by C. W. Hayes of the U. S. Geological Survey, who made important additions to both geographic and geologic knowledge. Since the acquisition of the territory, the coast survey has been steadily at work charting the shore line, and much was learned of the geology of the littoral province by Wm. H. Dall, long attached to that organization. John Muir's fascinating accounts of the glaciers of Alaska attracted widespread attention, and a number of expeditions were sent north to study them.

By all these means considerable geologic data were accumulated, though actual surveys were entirely lacking. A few official publications made reference to the mineral deposits, but these statements were unreliable because based purely on compiled information, and were taken at their true value by the public, which paid small heed to reports of valuable ore bodies in this northern field.

Systematic Surveys.

As year after year placer gold continued to be brought from the Yukon region and mining along the coast continued to expand, there arose a demand for more exact information. This led to a small appropriation which enabled the United States Geological Survey to send G. F. Becker and Wm H. Dall north to study the coal and gold deposits along the Pacific coast in 1895, while the following year J. E. Spurr, with two others, visited the gold placers of the Yukon. These two expeditions represent practically the beginnings of geologic surveying in this province.

Public attention was focused on Alaska by the discovery of the rich placers of the Klondike in 1896. Though these deposits lay in the Canadian-Yukon, it was close to the boundary, and the public generally regarded all of Alaska as lying within the gold field. Congress in 1898 increased the appropriation for Alaskan surveys and has since that time been liberal in supplying funds for this purpose.

There was an urgent demand for immediate information about routes, conditions of travel and occurrence of mineral wealth, on the part of the thousands who had started, or were about to start, north. Plans had to be formulated and parties organized in great haste, for the money did not become available until about the end of February. The task which confronted the Geological Survey was far from being easy. But little was known of this vast region which stretched toward the pole, much of which was locked in the ice over half the year. The field of operations could be reached only by long journeys by sea and land, and there was little in the way of experience to base the plans upon. Thanks to Spurr's journey into the Yukon, something was known of the conditions of travel, and the first season's plans were largely formulated by him. It appeared that the most important work was to make explorations to determine the geographic features and, as far as possible, to establish the distribution of the placer gold. Detailed surveys were out of the question; with the funds available they could not be made rapidly enough to meet the public demand. Moreover, so little was known of the region, that it was impossible to make choice as to which were the more important districts. It was, therefore, necessary to precede areal surveys by a system of explorations. Such had been the procedure in the western part of the United States during the preceding half century. The explorer was the first in the field, and it was only after the unknown regions had been honeycombed by many explorations that areal surveys were undertaken.

The routes leading inland from the coast appeared of first importance, and hence received the first attention. A bold mountain barrier stretches along the entire shore line of Alaska, as far west as Cook Inlet, and, previous to 1898, inland travel had crossed the barrier only at Chilkoot Pass, which leads to the Yukon through northern British Columbia. To the west two large rivers, the Alsek and the Copper, empty into the Pacific. Both had been traversed by white men and reported as unnavigable. Of a third, the Sushitna River, emptying into Cook Inlet, little was known. The problem was to seek a feasible route which should avoid traversing Canadian territory, and an important part of the first year's plan was explorations looking to this end.

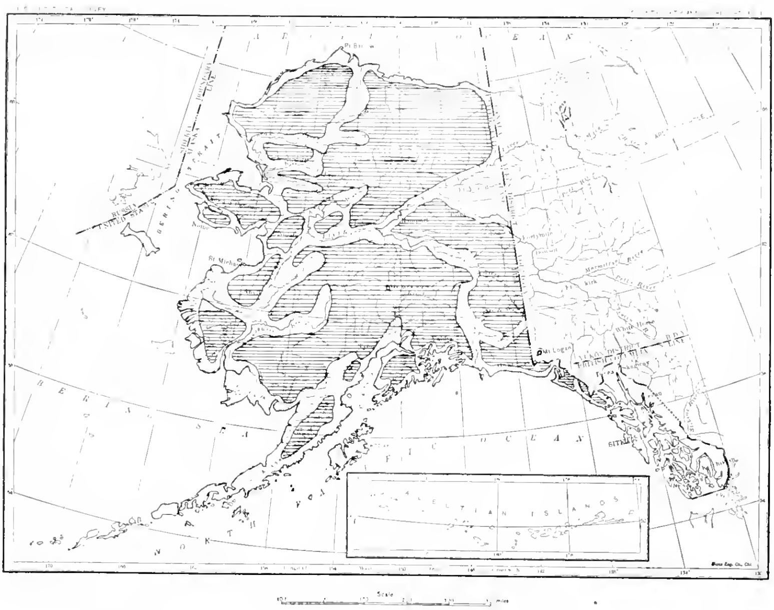
In cooperation with the War Department, one geologist explored inland from Prince William Sound, while another mapped a route from the head of Cook Inlet. A Geological Survey party carried on an exploratory survey up the Sushitna River and discovered a low pass into the Yukon basin. The Alaskan Range, which lies west of Cook Inlet, was traversed by another party, which found a broad pass into the Kuskokwim, which it descended, and, making a broad circuit, reached the Pacific coast again after traversing the Alaskan Peninsula. Two parties crossed to White Pass, then being used by thousands of gold seekers, and descended the Lewes and Yukon rivers in canoes. One of these ascended the White River, portaged to the Tanana, and continued down that stream to the Yukon. The other surveyed an area of about 2,000 square miles adjacent to the International Boundary and lying close to the Klondike gold fields.

The personnel of the four expeditions last mentioned included a geologist and a topographer, the senior of the two being in command. These officers were selected from the staff of the survey, among those who had had from five to twenty years of training and who were believed to have special aptness for exploratory work. From four to six canoeists, cooks, etc., completed each party, and these were picked among those who had rendered faithful services to the Geological Survey in other fields. It was important that they should be such men as could be relied upon in emergency, and particularly such as would not desert the party during a gold excitement.

As most of the surveys were to be along rivers, canoes were determined upon as means of transportation, and careful consideration led to the choice of those of the voyageur type, built in Canada. These boats, which were propelled with paddles and poles, combined the quality of staunchness with lightness and durability. A canoe from eighteen to nineteen feet long, weighing about one hundred and twenty-five pounds, was provided for every two men. It would carry a load of half a ton, and could be transported across a portage by its crew. The camp equipment, of the simplest character, included a sleeping bag for each man, a small mosquito-proof tent for every two men, a light cooking outfit, axes and a few tools. Not the least important part of the equipment was the repairing outfit, including some strips of cedar which were carried in each canoe, for the boats were so light that it was impossible to escape occasional injuries when running rapids. A light carbine with a hundred rounds of ammunition was carried in each canoe. The topographer was provided with a light theodolite and plane-table, while the geologist carried only a few hand instruments and cameras. Each member of the party was obliged to limit his personal baggage to the barest necessities; but was provided with mosquito-proof head-dress and gloves. The equipment of six men, aside from eatables, on a journey of four to five months, did not exceed 400 pounds in weight.

For the first season's work the provisions were limited to a very simple ration, consisting of little more than bacon, beans, flour and coffee, with a little butter, sugar, dried fruit and some farinaceous foods. The simplicity of the rations made it possible to reduce its weight to less than three pounds per man a day. Experience has shown, however, that there is economy in carrying more variety of food, as it keeps the party in better health and spirits. All perishable supplies were double-sacked and made absolutely water-proof. The wisdom of this precaution was many times made evident when the canoes were overturned or injured.

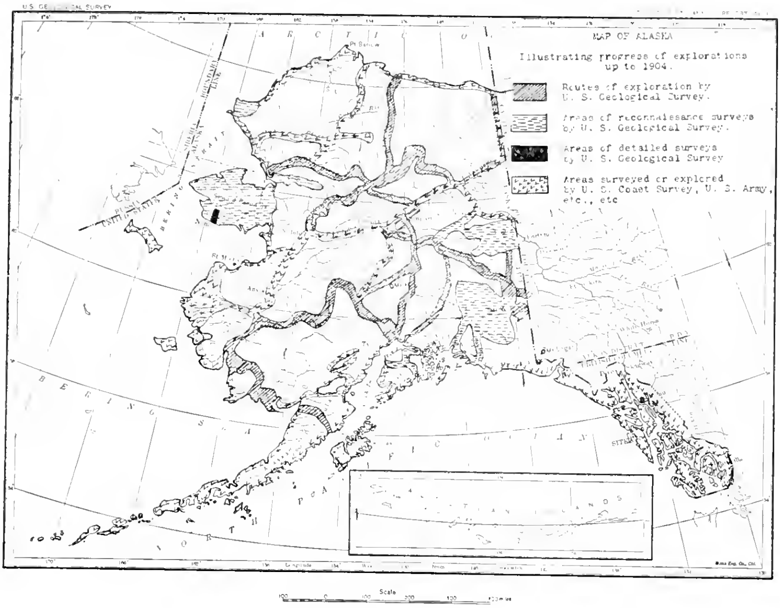
The methods of travel were practically the same for all the parties.



1. Map of Alaska, illustrating progress of exploration up to 1904.

Up-stream journeys were made by dragging the canoes with ropes, called 'tracking,' by which from two to ten miles a day could be accomplished, depending on the swiftness of the current and the character of the banks. If conditions were favorable, recourse was had to poling, by which much better time can be made. When the head of canoe navigation was reached, explorations into another watershed were made and a portage route determined upon. Then, if necessary, a trail was chopped and bridges built. Finally, the whole outfit was carried over by the members of the party. The longest portage made by a survey party was eighteen miles; but the work of transporting half a ton of supplies for such a distance is almost heart-breaking.

The methods of survey were determined more or less by the means and rapidity of travel. In most cases it was possible to make a fairly



24. MAP OF ALASKA, SHOWING UNEXPLORED AREAS IN 1895.

accurate reconnaissance map, with elevations indicated by contours; but where time pressed, a canoe traverse, with estimated distances, was substituted. Fortunately it proved possible to carry a rough triangulation, checked by latitude and azimuth observations, throughout much of the explored regions. The topography was sketched, on a field scale of about three miles to the inch, with the aid of a plane-table. Altitudes were determined as far as possible by vertical angles, but in many instances depended solely on the readings of aneroid barometers. Contours were sketched at intervals of 200 feet, or, if the topography was very rugged, 500 feet. In some cases it was possible to run stadia lines along the rivers, and salient topographic points were located by intersections. Though some of the journeys were accomplished under exceeding difficulties, in no instance were the surveys entirely interrupted.

The movements of the party were guided more by the requirements of the topographic than of the geologic surveys, and the geologist was perforce required to get such information as he could. Continuous series of notes were kept and specimens were assiduously collected. Special attention was given to the occurrence of placer gold and other metalliferous deposits, but all phases of geologic problems were studied as far as circumstances would permit. Probably the most important scientific results were those that had to do with the general physiographic problems. In most cases only the broader features of the stratigraphic succession could be determined, but even these results, bearing as they did on the geology of an important part of the American continent, proved of value. The work that has since been done has shown that it is in Alaska that we must seek the meeting-point of the stratigraphy of the old world and the new.

The methods and plans for the first season's work have been presented in some detail, as they afford an insight into the difficulties encountered and the character of the work. During the following winter the more important economic results were thrown into popular form for immediate publication. It is no exaggeration to state that, had it been possible to give to the public a year earlier the information obtained during this first season, *i. e.*, before the Klondike rush began, hundreds of thousands of dollars might have been saved: first, by directing the inland travel along the best routes, and, second, by furnishing a clew to the general distribution of the placer gold.

Thanks to the increased knowledge of the conditions of travel, and of the general geography, it was possible to direct the second season's work much more intelligently. It was discovered that horses could be used, which gave the parties far more mobility. During this season the explorations of the Yukon basin continued, and an examination of the newly discovered Nome placers was made. The latter, then thought to be a mere incident in what was considered more important work, proved to be of first interest to the public. A brief account of this gold field was published and placed in the hands of a large percentage of the thousands who started for Nome in the spring of 1900.

2*B*. MAP OF ALASKA, SHOWING UNEXPLORED AREAS IN 1905.

At the opening of the third year, explorations had been carried over so large an area that it seemed wise to defer their continuance until some areal surveys could be executed. These were so vigorously pushed that at the end of the summer nearly 15,000 square miles had been mapped. Since that time the areal work, both geologic and topographic, has held first place, though explorations have not been entirely neglected. The most notable of the explorations was made in 1902, when a small party, under the leadership of W. J. Peters and F. C. Schrader, starting in the dead of winter, made a 1,400-mile journey with dog teams. When the ice broke they continued their explorations in canoes, reached the arctic divide, portaged across and descended the Colville River to the Polar Sea. There they skirted the coast westward, rounded Point Barrow, the northernmost cape of Alaska, and finally reached Nome.

Results.

A comparison of the two maps here reproduced will indicate the progress of the areal surveys, and this matter is summarized in greater detail in the following table.

	Sq. Miles.
Explorations by U. S. Geological Survey	80,000
Geologic and topographic reconnaissance surveys	60,000
Explorations by other departments	50,000
Coastal province, shore line surveyed by coast survey and some geological surveys made by geological survey	120,000
Unmapped and practically unexplored	310,000
Total area of Alaska	620,000 ±

Besides this about one thousand square miles have been surveyed in great detail. The above statement does not include the extensive special investigations of mineral resources which have been made, for which about twenty per cent. of the total appropriations has been used.

It is difficult now to realize how little was known of Alaska previous to 1896. The general courses of the larger drainage features were laid down on maps, but only in a very crude way. The coastal mountains were known, but the two great inland ranges, one of which contains the highest peaks on the continent, were hardly indicated on any map. Only a few of the passes were known and the altitude of not a single point away from the coast had been established. Now all but two of the larger rivers have been surveyed, and contour maps have been made of over 150,000 square miles. All of the larger geographic features have been outlined by the network of explorations which have been extended over the entire territory. There are no new mountain ranges to be discovered, though there are several which are but imperfectly known.

In the purely geologic work the results are still more striking.

While a decade ago only a few facts about the geology of the coast province was known, it has been possible now to prepare a preliminary map of the geologic features of over half the territory. The stratigraphic studies are of still greater interest, for they have shown the presence of many horizons in northwestern America that were previously unsuspected.

The economic results have been touched upon in the previous pages. The proof of their comprehensiveness lies in the fact that there is not a single mining district in Alaska which has not been reported upon. An inquiry in regard to the mineral resources of any part of Alaska, coming to the office of the survey, is now met with a printed report containing the latest and most authentic information.

While much has been accomplished, much remains to be done. Over half the territory has not been covered by even reconnaissance maps. Even these will not suffice in regions of important mineral production, where often hundreds of thousands of dollars are being invested, and detailed surveys, comparable to those made in the states, are demanded. Railways are in construction, involving expenditures of millions of dollars, and, though these are being built without any direct governmental aid, such as is being extended in the Philippines, the capitalists who are financing them have a right to expect that the government will at least explore routes and furnish reliable information regarding the resources of the region to be traversed. It was this liberal policy which hurried the construction of the transcontinental lines a generation ago. There are parts of the territory which have considerable prospective agricultural value, and their settlement will be hastened, if their topography and resources are made known. Roads must be constructed, and this can only be properly done on the basis of a full knowledge of the geology and topography.

In its relation to the federal government, Alaska differs from any other possession of the United States. Though heavily taxed, the 30,000 white residents have no voice in the making of their laws. Porto Ricans and Hawaiians have territorial government, the Filipinos have their commission, but Alaska must depend entirely on the benevolent paternalism of a legislative body 5,000 miles away. In this northland there are thousands who have been struggling with adverse conditions to open up a new land, who have thereby benefited the whole country. These people have a right to expect that the people of the United States will come to their aid in the development of Alaska.

WHAT IS AN EAR OF CORN?

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IT is generally thought that corn (*Zea mays*) originated from some plant like teosinte (*Euchlæna*), and that the ear is the result of the fusing together of a number of two-rowed pistillate spikelets, such as are found in *Euchlæna*. Hackel[1] evidently holds this view, for he describes the pistillate flowers of corn as being similar to those of *Euchlæna* and borne on spikes, except that "the pistillate spikes (originally by monstrous or teratological development?) are grown together into a spongy continuous club-shaped body (the 'cob') upon which the four to eleven double rows (each sessile upon a low longitudinal

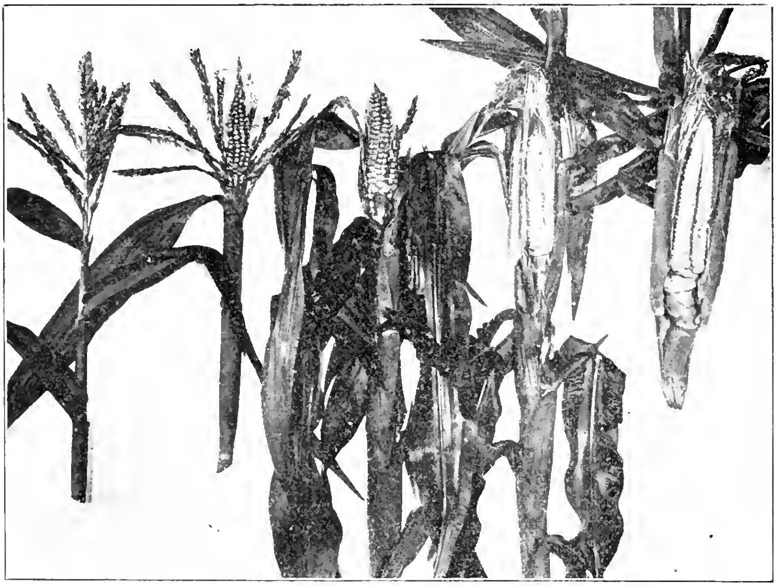


FIG. 1. PHOTOGRAPH SHOWING STEPS OF EVOLUTION OF THE CORN TASSEL INTO AN EAR.

elevation, that is limited by a long, shallow furrow on each side) correspond to a single spike of *Euchlæna*." This view is also accepted by Harshberger,[2] who made a careful study of the corn plant, and I believe is the theory generally accepted as to the origin of the corn ear.

[1] Hackel, 'The True Grasses' (trans. by Scribner and Southworth), page 38.

[2] Maize, 'Contributions from the Botanical Laboratories of the University of Pennsylvania, pp. 75–202, 1893.

I have often noted abnormal developments or possible reversions which have suggested to me another explanation. These offer much evidence that instead of the ear originating from the fusion of a number of two-rowed spikes, it developed directly from the central spike of some tassel-like structure similar to the well-known corn tassel. Tassels may be found where only a few pistillate flowers have been formed on the central spike and others with more and more such

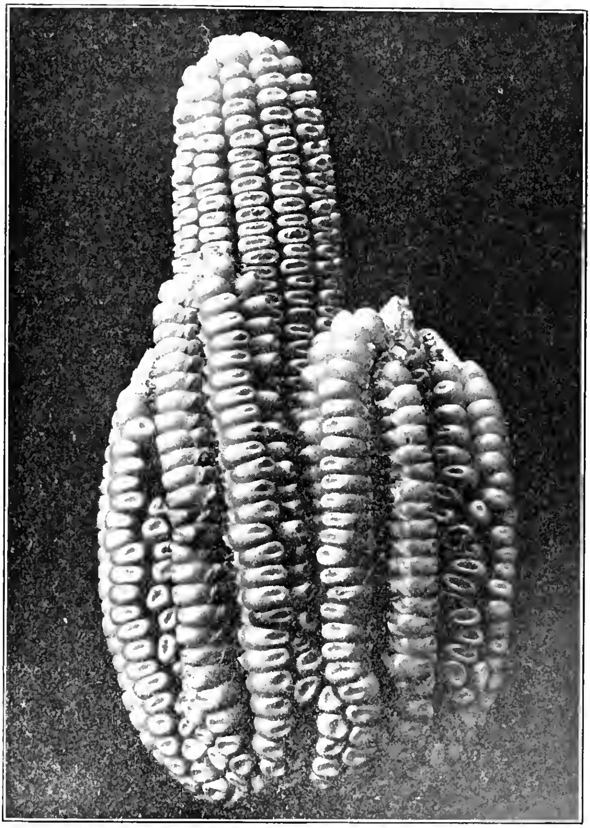


FIG. 2. A CASE IN WHICH WE HAVE A WELL DEVELOPED TWELVE-ROWED EAR corresponding to the central spike of a tassel and surrounded at the base by a number of four-rowed 'nubbins' that correspond to the lateral branches.

flowers, up to where a fair-sized ear has been developed. The accompanying photograph (Fig. 1) shows some of the steps from a normal tassel up to a perfect ear. Note that in the first step the plant is almost normal (at the left), in the second the central spike of the tassel is fairly well developed into a small ear, the number of lateral branches has been somewhat reduced, and the internode below the tassel is somewhat shortened, so that the base of the tassel is partly enclosed. In the third step all the lateral branches have disappeared but two, and the ear-like structure is almost enclosed in the leaf sheaths; in the fourth step only the well developed central spike remains, and is entirely enclosed in the leaf sheaths, owing to the shortening of the internodes

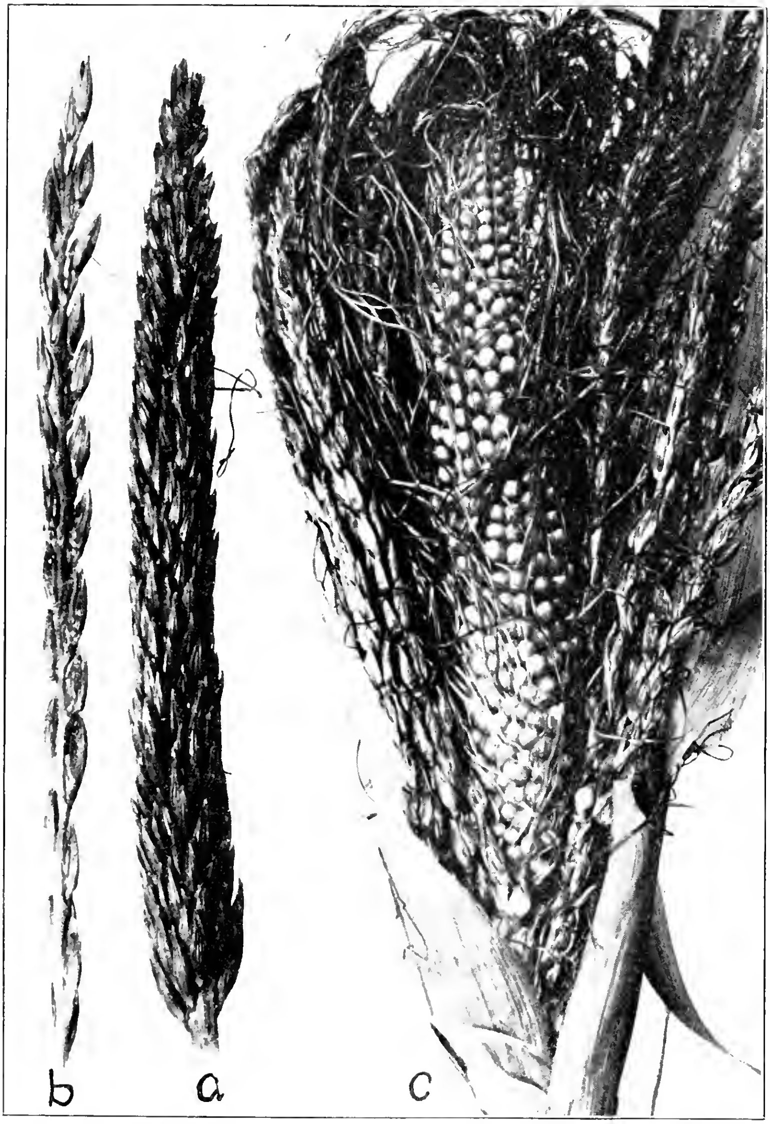


FIG. 3. *a*, Central spike of tassel bearing pairs of spikelets in eleven rows; *b*, lateral branch of tassel bearing pairs of spikelets in two rows; *c*, tassel in which central spike is developed into an ear.

below. The last step illustrates a well developed ear, also showing the much shortened internodes below, and the very greatly reduced leaves, which in the highest types of corn completely disappear, leaving only the leaf sheaths enclosing the ear. It is just as possible for the lateral branches to develop pistillate flowers as for the central spike, and they often do so. The accompanying photograph (Fig. 2) exhibits a case in which we have the central spike and also the lateral branches developing pistillate flowers. But ordinarily in evolution when one portion begins to develop it is at the expense of other adjacent parts. In such case, the development of the central spike of the tassel is accompanied by the disappearance of the lateral branches. By removing the surrounding 'nubbins,' we find that there is a normal ear in the center.

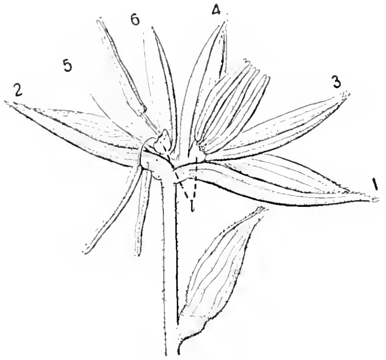


FIG. 4. STAMINATE FLOWER OF CORN (*Zea mays*). 1, First empty glume; 2, second empty glume; 3, first flowering glume; 4, first palet; 5, second flowering glume; 6, second palet; 7, lodicules. The upper flower matures first, but the palet and glume are smaller than in the lower flower.

The central spike of the normal tassel usually has from four to eleven rows of spikelets in pairs, making eight to twenty-two rows of corn when developed, while the lateral branches usually have only two rows of spikelets in pairs, making only four rows of grain when well developed.

It is interesting to note the morphological changes which take place in the modification of the staminate flower into the pistillate. The staminate spikelets are borne in pairs (sometimes in threes), one sessile, the other pedicellate, the pairs alternating. As already stated, the pairs of spikelets are borne in two rows on the lateral branches, and in four to eleven rows on the central spike of the tassel (Fig. 3). The structure of the staminate spikelet is shown in Fig. 4. The outer glumes enclose two sessile flowers, and are 7–12-nerved; flowering glumes are 3–5-nerved, the palet 2-keeled, lodicules 2, fleshy and truncate. There is usually more or less difference between the upper and lower flowers in a spikelet; the upper flower matures first, and the palet is larger than the glume, while in the lower flower the glume is larger than the palet (Fig. 4).

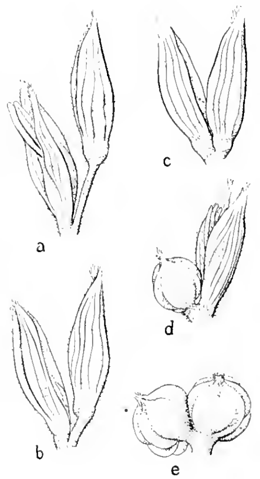


FIG. 5. MODIFICATION OF A PAIR OF STAMINATE SPIKELETS INTO A PAIR OF PISTILLATE SPIKELETS, *a*, *b*, *c*. The pedicellate spikelet shortens down until it becomes sessile. *d*, The sessile flowers become pistillate; *e*, both flowers become pistilate.

The first tendency toward the development of a pistillate flower is indicated by a shortening of the pedicellate spikelet until it becomes sessile (Fig. 5, *c*). This is accompanied by an increased difference between the flowers, as mentioned above. As modification progresses, the lower outer glume shortens and becomes thicker and more corneous. The palet and glume of the upper flower show a tendency to become

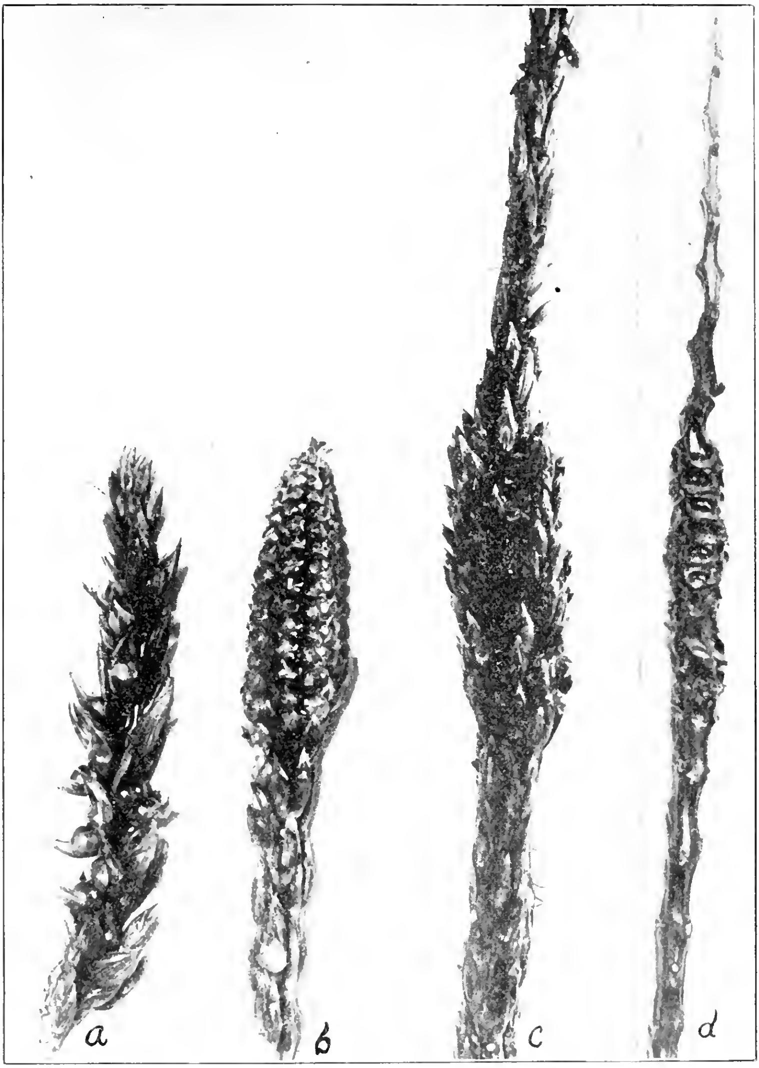
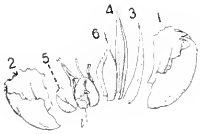
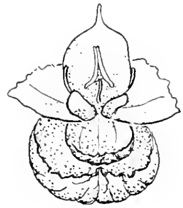


FIG. 6. SPECIMENS FROM CORN TASSELS: *a*, Branch of pod-corn tassel showing twinned grains; *b*, Central spike of tassel with tip developed into small ear; *c*, central spike of tassel developing pistillate flowers near middle; *d*, same as *c* with flowers removed to show tendency of central rachis to develop into a cob-like structure where pistillate flowers are borne.

more reduced, while the lower flower becomes practically abortive, except that the palet and glume are still of normal size. In the first stage after the flower has become pistillate (Fig. 5, *d* and *e*), the two





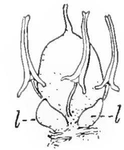


FIG. 7. VERY YOUNG PISTILLATE FLOWER FROM TASSEL OF POD CORN. Note difference between size of pistils and size and form of glumes and palets. The lower flower would probably be abortive.

FIG. 8. HERMAPHRODITE FLOWER The parts are all numbered to correspond with Fig. 5.

FIG. 9. HERMAPHRODITE FLOWER OF MAIZE (*Zea mays*). The anterior stamen is fairly well-developed, while the other two are mere remnants.

FIG. 10. HERMAPHRODITE FLOWER OF MAIZE (*Zea mays*).

outer glumes are found to be greatly thickened and somewhat corneous. The palet almost encloses the young ovary, the glume covering only a narrow space on the back (Fig. 8), and the tip of the ovary often protruding. The palet and glume of the lower flower (which is now entirely abortive) are more or less hyaline and closely pressed against the dorsal side of the grain. However, in all varieties of corn both flowers in a spikelet will sometimes be found well developed. Twinned grains are especially common in the tassels of pod corn (*Zea tunicata*) (Figs. 6 and 7). Sturtevant[3] mentions an ear of podded flint corn from Ohio in which the kernels were twinned in the pod.

Hermaphrodite flowers are sometimes found; in fact, in tassels where pistillate flowers are produced, they are quite common (Figs. 8, 9, 10). The stamens, however, are generally very much reduced or are rudimentary. The dorsal stamen seems to persist longest and will often be well developed, while the other two are

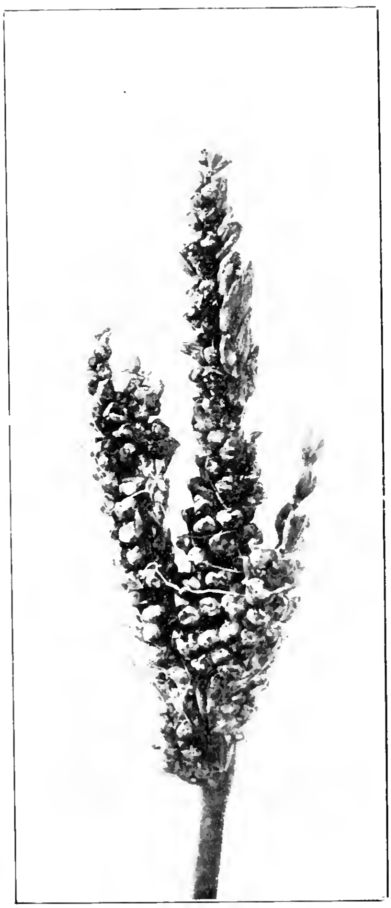


FIG. 11. THE KIND OF A TASSEL IN WHICH HERMAPHRODITE FLOWERS ARE VERY COMMONLY FOUND.

[3] *Bulletin of the Torrey Botanical Club*, 1894, p. 336.

rudimentary (Fig. 9). The lodicules are very prominent in the staminate flowers, and will usually be found more or less reduced in hermaphrodite flowers, but they entirely disappear in the pistillate flowers.

FIG. 12. PISTILLATE FLOWER OF DENT CORN, very young, carpel not yet closed. *r*, Rudimentary lower flower magnified 65 diameters.

The lower rudimentary flowers may be found in the pistillate flowers of all types of cultivated corn (Fig. 12). The abortive ovary is soon absorbed, but the palet and glume remain to form a part of the 'chaff' on the ordinary corn cob.

The development of the central spike into an ear

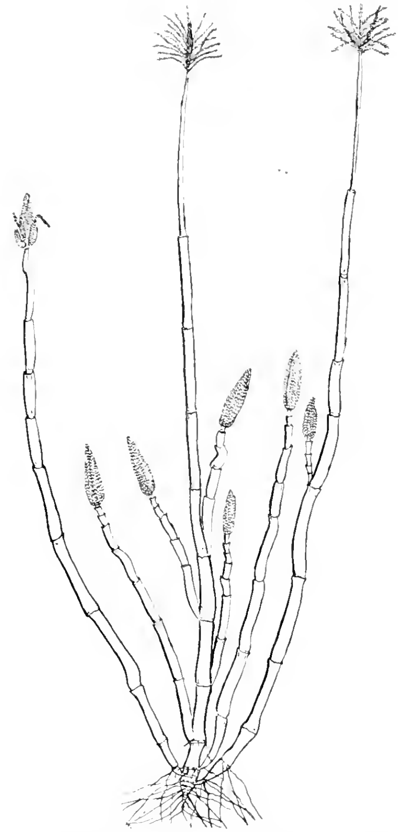


FIG. 14. DRAWING FROM PHOTOGRAPH OF A SWEET CORN PLANT TO COMPARE WITH DIAGRAM FIG. 13. Note that the number of nodes in the shortened ear-bearing branches corresponds exactly to the number of nodes in the main stem above point of attachment.

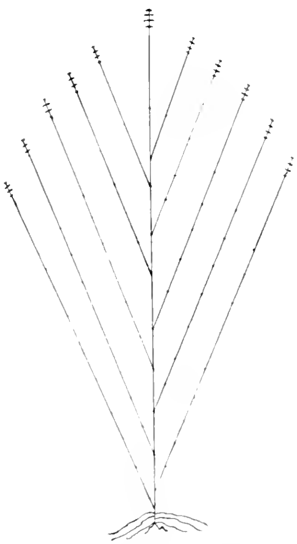


FIG. 13. DIAGRAM ILLUSTRATING PROBABLE STRUCTURE OF EARLY PROGENITOR OF CORN PLANT.

may now be easily traced. First, the pedicellate spikelet in each pair of spikelets becomes sessile so that we have a pair of sessile spikelets as in Fig. 5, *c*. Then the upper flower in each spikelet becomes a perfect pistillate flower, while the lower flower in each spikelet becomes an abortive pistillate flower. The pairs of spikelets on the central spike are in four to eleven or more rows, so that by the mere development of the central spike of the tassel into a pistillate spike, we have an eight to twenty-two-rowed ear. This accounts for the well-known fact that corn ears are *even* rowed.

My observations suggest to me that corn and teosinte may have had a common origin, and that in the process of evolution the cluster of pistillate spikes in teosinte were developed from the *lateral* branches of a tassel-like structure, while the corn ear developed from the *central* spike. It is probable that the progenitor of these plants was a large much-branched grass, each branch being terminated by a tassel-like structure, bearing hermaphrodite flowers. Fig. 13 is a diagram of such a plant. As evolution progressed, the central tassel came to produce only staminate flowers, these being higher and in a better position to fertilize the flowers on the lower branches. At the same time, the lateral branches came to produce only pistillate flowers, their position not being favorable as pollen producers, while, on the contrary, they were favorably placed to receive pollen. This differentiation in the flowers was accompanied by a shortening of the internodes of the lateral branches until they were entirely enclosed in the leaf sheaths, as shown in Fig. 1.

Fig. 14 is a sketch of the stalk and ears of a well-developed sweet corn plant after the removal of the leaves and leaf sheaths. It will be noted that the number of nodes in the ear-bearing branches agrees exactly with the number of nodes found in the stalk, above the point of attachment. If these branches were elongated to their normal length, we should have something similar to the diagram in Fig. 13. The lowermost branches usually arise at or below the surface of the soil. They develop their own root systems where they are in contact with the soil, and soon separate from the main plant and become independent plants bearing a proper tassel and ear, in all respects similar to the parent plant. Intermediate between the tassel-bearing branches and the first ear-bearing branches on the main stem there often may be found one or more branches, the tendencies of which seem to be about equally divided between ear-bearing and tassel-bearing, resulting in a structure combining the characteristics of both tassel and ear.[4]

[4] I wish to acknowledge indebtedness to Dr. Charles E. Bessey for helpful advice during the course of this investigation.

SPENCER FULLERTON BAIRD

By T. D. A. COCKERELL[1]
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SPENCER FULLERTON BAIRD was born at Reading, Pa., on February 3, 1823. He was the third child, as well as the third son, of Samuel Baird and Lydia Biddle Baird. Samuel Baird was a lawyer and a man of education and scholarly tastes, very much interested in natural history in a general way, although he could hardly be called a naturalist. He died when S. F. Baird was only ten years old; but it was from him, in those early years, that the latter got the original impulse toward the study of natural objects.

Professor Baird's ancestry, as we learn from Dr. Brown Goode, was English on one side; on the other Scotch[2] and German. His paternal grandfather was Samuel Baird, of Pottstown, Pa., a surveyor by profession, whose wife was Rebecca Potts. The Bairds were from Ireland, while the Potts family removed from Germany to Pennsylvania at the close of the seventeenth century. His great grandfather on the mother's side was the Rev. Elihu Spencer, of Trenton, who was one of the war preachers of the Revolution, and was so influential that, according to tradition, a price was set on his head by the British government; his daughter married William M. Biddle, a banker of an English family for many generations established in Pennsylvania.

After the death of Professor Baird's father, his mother, with her seven children, moved to Carlisle, the county seat of Cumberland County, Pa., where her nearest relatives were then living. Young Baird was educated at the grammar school at Carlisle, and at Dickinson College, in that city; graduating from the latter at the age of seventeen. The boys of the Baird family were all interested in shooting; but the oldest, William McFunn Baird, and the subject of the

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[1] I am greatly indebted to Miss Lucy H. Baird for information, for access to portions of Professor Baird's diary, and especially for some unpublished notes for a memoir of her father, written by herself. The last, with her kind permission, has been freely used and incorporated in the present work. I am also much indebted to the authorities of the Smithsonian Institution for permission to examine Baird's letter-books; and to Drs. Dall, Ridgway, Gill, Mason and others for much kind help. I have also availed myself of the published memoirs of Baird, especially that of Dr. Brown Goode, with the accompanying bibliography (Bull. 20, U. S. Nat. Museum).

[2] Properly speaking, 'Scotch-Irish,' *i. e.*, from Ireland, but of Scotch blood.

present memoir at a very early age became interested not merely in killing birds, but in studying them. These brothers in their early 'teens' began to form a collection, of which they were joint proprietors. This was really the nucleus of what is now the National Museum series, and possesses a historical interest in relation to the museum similar to that possessed by the Sloane collections in relation to the British Museum. It is said that some of the early specimens were prepared 'by the simple process of evisceration, followed by stuffing the body-cavities full of cotton and arsenical soap'; but the later ones were admirably prepared, and all are alike precious to those who are interested in the foundations of American ornithology.

Spencer Baird was ready to enter Dickinson College a year before he actually did so; but Miss Baird informs me that he used to say that he regretted that he had not been kept back longer, as he thought that a boy of thirteen was mentally too immature to reap the full benefit of a college course. The opportunities for scientific study in the college were, of course, very small in those days; but there is no doubt that Baird at this time had fully acquired the 'scientific spirit,' and all he needed was reasonable opportunity. His diary, beginning in 1838, when he was only fifteen years old, shows the same close observation and painstaking exactness which characterized the work of his later years. Thus we read on May 25, 1839:

> About one A.M. gust came up; light wind—some thunder—rained violently for one quarter hour. Very warm all day. About two P.M. went out to creek with gun. Shot some small birds, principally flycatchers. Home at seven. Skinned and opened birds until ten.

Another entry in the diary reads:

> 15th, Saturday. Rode part of way home; shot six robins, young and old, under mulberry tree; warbling vireo; read-head, and downy woodpecker.

A later note, dated December 1842, states that the last-mentioned woodpecker was apparently a distinct species, and was named after Baird by J. G. Bell, of New York.[3] 'It was on a high horizontal limb in the first bottom.'

Dickinson College must have been somewhat in advance of the times, for lectures on zoology were offered. The diary under June 18, 1839, has the record, 'Attended one of Mr. Hamilton's lectures on zoology to the senior class in the afternoon.' Baird was then a junior, but no one could deny his fitness to rank with the seniors in zoology.

After leaving college, Baird continued his natural history studies with unabating zeal, and it is evident that at this time his mission in

[3] It was, apparently, never published. I could find no reference to it, and Dr. Ridgway, to whom I applied for help, is also unaware of any such bird having been published.

life was fully decided, though this was not so apparent to his relatives as it now is to us. It must be remembered that in 1840 zoology had not received the recognition in America as a serious and important branch of study that it has to-day, largely as the result of Baird's work. There was no great National Museum; there were no zoologists occupying important and enviable positions; there were hardly any opportunities for the publication of zoological work. It is not surprising, therefore, that young Baird's ultra-devotion to this subject was regarded with somewhat modified approval. Here was a young man, manifestly talented and able to make his way in the world, giving himself over to birds and beasts, snakes and salamanders; things which were very well to occupy the leisure moments of a gentleman, but were not calculated to bring either fame or fortune! Nevertheless, Baird went his way, for he could not do otherwise; and even in those days he had a staunch supporter in his grandmother, while his mother was too wise to interfere with his plans.

However, it appeared necessary to select a profession of some kind; and, like so many other naturalists, he became a medical student. In 1841 we find him going to New York, where he lived during one winter, part of the time with Dr. Middleton Goldsmith, and attended a course of lectures at the College of Physicians and Surgeons. He never formally completed his medical course, but in 1848 he received the degree of M.D., *honoris causa,* from the Philadelphia Medical College. Baird's life in New York is told in brief paragraphs in his diary. I made the following extracts:

Saturday, 6th. In evening with Dr. Goldsmith to see Mr. Audubon. Found him unlike my preconceived idea of him.

Audubon was, of course, at that time *the* ornithologist in this country, and Baird became his legitimate successor in the science. The first meeting (it appears that they had previously been in correspondence) led to an almost immediate intimacy, as the dairy shows:

8th, Monday. Heard Watts on osteology, and Torrey on chemistry.

9th. Round to Mr. Audubon, 86 White St., to see his exquisite drawings of quadrupeds, all finished size of life. Helped Dr. Goldsmith dissect a fox-squirrel for Mr. Audubon. Heard Dr. Torrey in evening.

12, Friday. Mr. Audubon called at the office (Mr. Goldsmith's, with whom I am staying) to see me.

He very soon became acquainted with all the prominent naturalists in New York at that time, and was well received everywhere.

23rd, Thursday. Dissecting opossum all day.

In morn went with Major Leconte to see Dr. DeKay at the Lyceum, who is preparing the State account of the Zoological Survey. He has all the animals of New York, figured. At Mr. Audubon's where saw some live *Neotoma floridana* (a species of woodrat) from South Carolina. Took some birds to show to J. G. Bell, when met J. P. Giraud, with whom I went to see his collection of birds, which is the finest I have seen. Gave him a Cape May warbler. He gave me a Red Phalarope and a copy of his little tract called Descriptions of 16 New Species of North American Birds from Texas.

Wednesday. At Mr. Audubon's in morn for two hours, drawing.

9th, Thursday. Thanksgiving Day. No lecture. In morn at Mr. Audubon's, taking drawing lessons; started with *Tyrannula*.

Although he took lessons from so great a master, he never became very skilled with the pencil; largely, of course, because the pressure of other work prevented him from spending much time in drawing. No doubt, however, his knowledge of the minute structure of *Tyrannula,* gained in the way just described, helped him to discriminate and describe two new species a few years later.

14th. Commenced drawing Cedar Bird at Mr. Audubon's. He is drawing common rabbit.

18th. Mr. Audubon gave me a copy of the letter press of his Biography of Birds, five volumes, royal octavo. Obtained a number of rare American bird skins from Peale, for which I am to send Helices, fossils, coins etc.

28th, Thursday. Went down to the Thomas P. Cope Liverpool Packet to see Mr. Nuttall, who is about starting for England. He has inherited an estate of $5,000 per annum, at Prescott, near Liverpool. He invited me to come and see him at it.

Mr. Nuttall was, of course, the distinguished botanist and ornithologist. Circumstances never permitted the acceptance of the invitation.

Baird now went to Philadelphia for a short vacation:

29th. Went with Mr. Woodhouse to Mr. John Cassin's.

The veteran ornithologist Woodhouse only died recently. Cassin became one of Baird's most intimate friends, sharing with him in the interest of every ornithological discovery. The old colored man, Mr. Solomon Brown, who faithfully assisted Baird during his whole life in Washington, tells me that 'old John Cassin used to come down from Philadelphia about once a month to look over the collection; and he and Baird were just like brothers.'

To return, however, to the diary:

30th. In morn at T. A. Conrad's. Saw a fine collection of Siberian fossils.

31st. Took tea with Dr. and Mrs. Marshall at Isaac Lea's. Saw his very extensive collection of fossils and shells.

This also was in Philadelphia. Conrad and Lea were the famous conchologists, Lea being especially devoted to the freshwater mussels.

Baird was certainly not one of those people who wait for opportunities to engage in research. He not only went everywhere and met every naturalist within reach, and picked up all the information he could from them and from books, but he was making discoveries on his own account. Although he is known to us as a student of vertebrate zoology, he took a keen interest in botany, anthropology and many other subjects. The diary of January 17, 1844, has this item: 'Commenced making extracts from Torrey and Gray's Flora.' He needed the use of a microscope, and this was loaned to him by Dr. Haldeman, the well-known naturalist, who befriended him in many ways. In 1844 we find him visiting Dr. Melsheimer, the coleopterist. The year 1843 was one of great activity in field research and collecting. The diary says: 'Walked about 1,400 miles this year. Used about 70 lbs. shot, 8 lbs. powder, and 1,800 caps.'

Not only did Baird add much to what was known of the distribution and characters of the birds and quadrupeds of Pennsylvania, but five entirely new ones were discovered in the vicinity of Carlisle, namely, two birds, a lizard, a frog and a salamander. The birds were the yellow-bellied and least flycatchers; they formed the subject of Baird's first published paper, which appeared in the *Proceedings* of the Academy of Natural Sciences of Philadelphia, in 1843. This paper, which was the joint product of the brothers, William and Spencer, was entitled 'Descriptions of Two Species, supposed to be New, of the Genus *Tyrannula,* Swainson, found in Cumberland County, Pennsylvania.' The birds were named *Tyrannula flaviventris* and *Tyrannula minima,* and are to-day well-known species; they are now placed in the genus *Empidonax,* to which Baird subsequently removed them.

The salamander, *Pseudotriton montanus,* was published in 1849; it is now known as *Spelerpes ruber montanus* (Baird). The lizard, published in the same year, is *Eumeces anthracinus* (Baird), while the frog, not published until 1854, is known as *Chorophilus feriarum* (Baird). It will be admitted that these were interesting finds in a region so well known as Pennsylvania toward the middle of the last century; evidence that Baird was using his own eyes, and not depending too much upon the work of others. Another discovery, of somewhat later date, was an apparently extinct rat of large size, the remains of which occurred in the bone caves of Pennsylvania. This animal was described in 1857 as *Neotoma magister;* but many years afterwards a rat was found still living in Pennsylvania, the bones of which do not seem essentially different from those of Baird's animal, and it is thought by some that the two are identical. This was the only fossil animal ever described by Baird.

In 1844 the Baird brothers published a second paper, a 'List of Birds Found in the Vicinity of Carlisle, Cumberland County, Penna., about Lat. 40° 12′, N. Lon. 77° 11′ W.,' which appeared in the *American Journal of Science and Arts.* It is characteristic of Baird's love of precision that he should cite the latitude and longitude in the title. The list enumerated 201 species observed by the brothers, with particulars about their time of appearance, abundance, etc. In 1845 a revised edition appeared, enumerating 202 species from the county, and revising the nomenclature of seven species, to bring it in accord with the strict law of priority. This edition was by S. F. Baird alone, William Baird having entered upon the practise of law, and given up active participation in scientific pursuits.

It is said that a prophet is likely to be without honor in his own country; but Baird was one of those rare men who, without pushing themselves forward, succeed in enlisting the sympathy and support of all those about them. An amusing story is told, that once he was engaged in hunting for Indian arrow-heads and other remains in a field, and some men working in an adjoining field stopped to see what he could be about. After watching him for some time, they concluded that he was an escaped lunatic, and, procuring a rope, approached with the intention of capturing him. Baird, looking up, saw them coming, and immediately began to exhibit to them his finds, and explain about the past history of the Indian tribes. In a moment, he was giving a lecture on anthropology to a thoroughly interested and admiring audience, and it is reputed that some of them subsequently took up the same study. Similarly, the doubts which may have been entertained by his family and friends faded away, and Dickinson College, in his own home town, was glad to elect him professor of natural history in 1845, when he was but twenty-two years of age.

The appointment at first was little more than a token of regard, for there was no pay and there were no duties assigned. Both, however, began simultaneously in 1846; and in the same year he married Miss Mary Helen Churchill, the only daughter of Sylvester Churchill, Inspector General U. S. A. It is perhaps not unfitting to cite here the remark of old Mr. Solomon Brown, that "Baird was as near a perfect man as I ever met with, and I do not see how such a man could get a wife equal to himself; but that is what he did, for she was as sweet as he was," and, added Mr. Brown, "I never saw either one angry."

Baird as a teacher was indefatigable and resourceful. He had nothing resembling the luxurious laboratories of to-day, and it was necessary for him in many instances to manufacture his own apparatus. It was scarcely possible at that time to find text-books covering the necessary ground; but, in any event, it was no plan of Baird's to study books to the exclusion of out-of-door nature. Whenever it was possible, chiefly on Saturday afternoons, he took those of his classes who cared to join him on long walking trips in the neighborhood of Carlisle, botanizing, geologizing and collecting the mammals, birds, fishes and reptiles of the neighborhood. Several of the students so trained afterwards went as collectors with various exploring parties, and did good service in procuring material for the National Museum. In 1848 Baird applied for and obtained a grant from the Smithsonian Institution (then recently established) for the purpose of working up the natural history of southeastern Pennsylvania, and especially for the exploration of the bone-caves already mentioned. This was the first grant for original research made by the Smithsonian; no large amount, but wisely and well bestowed.

In 1850, Professor Henry, the secretary of the Smithsonian Institution, requested the regents to allow him to appoint an assistant secretary in the department of natural history, to take charge of the embryo museum, and to aid in the publication and other interests of the establishment. This being granted, he at once selected Professor Baird, who immediately accepted and entered upon his new duties.[4] In doing so, he brought to the museum his own valuable collections, and from that time until his death devoted himself absolutely to performing and assisting scientific work on behalf of the American people.

The dream of Baird's life had been the creation of a museum, and to this end, as far as the policy of the Smithsonian Institution would permit, he bent his energies. The situation was a difficult and a delicate one, and we marvel that he was able to completely gain his ends without friction or controversy. Professor Henry, in organizing the Smithsonian, performed an exceedingly difficult task with skill and wisdom. There were all sorts of rival claimants for the disposal of the fund, some wishing to have literature provided for, others different branches of science, and many desiring that the money should be put into a large library. It was perfectly evident to Henry that, if he listened to all these demands, the Smithsonian fund would be frittered away and nothing of much consequence accomplished. He therefore laid stress on Smithson's terms of bequest, in which it was stated that the institution should be for the increase and diffusion of knowledge, and opposed the numerous elaborate plans presented to his notice. It was no part of Henry's intention, when he secured the employment of Baird, that the latter should build up a great National Museum; yet this was the very thing that Baird desired and hoped to do. Both men were right in the light of what they knew; the museum plan would probably have wrecked or crippled the Smithsonian in the hands of any one but a genius like Baird; but as it was, it gradually and naturally evolved, finding for itself public support, and in due course meeting the full approval of Henry himself. Those who were intimately acquainted with the two men speak only of their great attachment to one another, and the total lack of friction in the details of administra-

[4] In Marcou's 'Life of Agassiz,' Vol. II., p. 74, the matter is presented in a somewhat different way, but not quite accurately. For example, as I learn from Miss Baird, Geo. P. Marsh was a member of the House of Representatives, not a senator; and he was acquainted with Baird prior to 1848. Furthermore, Henry was of course well aware of Baird's existence and his qualifications.

tion. In this and numerous other cases, Baird's success was due not to any form of cunning, but rather to his straightforward simplicity and manifestly unselfish devotion to his work.

In Baird's first report as assistant secretary, published in 1851, he called attention at some length to the important work needing to be done in zoology, botany and geology. It was the declared policy of the Smithsonian, at that time, not to attempt to cover the whole field of science, but to attend to those subjects which had been neglected by others. Very well, said Baird: accepting fully this plan, we must point out that we lack information on—and he proceeded to specify in detail the very numerous investigations crying out for workers, and the splendid opportunities that lay before those who should take them up.

He was by no means content to work solely through official channels. In every possible way he stirred up the enthusiasm of collectors, aided those who desired to study and persuaded travelers to secure material for the museum. When going through his letters of the year 1859, I found evidence of his wonderful perseverance which is worth citing. In March of that year he wished to send the well-known naturalist and traveler, Robert Kennicott, to the region of the Hudson Bay for specimens. The Smithsonian had absolutely no funds for such a purpose, and with any ordinary official that would have settled the matter. Not so with Baird; starting a subscription list with fifty dollars out of his own pocket, he wrote to most of the prominent naturalists of that day, asking them to subscribe what they could and receive a corresponding part of the collections. The response was prompt and satisfactory, and about $500, the amount asked by Baird, was raised. I have before me a copy of the list of subscribers containing such well-known names as those of Cassin, Brevoort, Lawrence, Ostensacken, Cresson and Lea. The Smithsonian itself did finally put in $50, in addition to the sum personally subscribed by Baird on its behalf.

About the same time Baird wished to send John Xantus, a Hungarian resident in America, and a skilled naturalist, to the little-known peninsula of Lower California. It was evidently impracticable to raise two five-hundred dollar subscriptions; but Xantus must go. It was ascertained that the U. S. Coast Survey wished to send a man to that region to examine the tides; why not Xantus? So it was readily arranged, and off he went, furnished with all facilities for collecting specimens.

Thus, without any visible resource to begin with, two important expeditions were despatched. Those who know something of the zoology of America do not need to be reminded of the great results accomplished in each case. It is hardly possible to open a work on any large group of American animals without finding references to the fruits of those two expeditions.

If Baird asked contributions from residents in distant parts, it was all for the sake of science, as they well know; yet he at his end did not spare himself in serving the personal needs of his correspondents. At one time we find him going out to purchase shoes for a whole family in Costa Rica; at another, Mrs. Baird's cooperation was secured in the selection of a 'lady's silk,' intended for the wife of a resident in a far northern post. It was no easy matter to select the cloth, not even knowing the color of the lady (she turned out afterwards to be a half breed), but the purchase was entirely satisfactory.

Baird only entered upon his labors at the Smithsonian in October, 1850, but a year had not passed before he received important and abundant materials from the west. The following letter to the distinguished botanist, Dr. George Engelmann, of St. Louis, Mo., is sufficiently characteristic:

SMITHSONIAN, WASHINGTON, Sept. 30, 1851.

Dear Doctor:

The box arrived safely during my absence, and on my return a few days ago I hastened to open it. I was enchanted out and out with the perfection of the packing, and the interest of the contents, which greatly exceeded my anticipations. Much obliged to you for the trouble you had.

I am glad that you are at work for Agassiz and myself. Make a big collection, and don't spare the liquor. Remember we want everything. Keep Lindheimer spurred up [Lindheimer was a well-known botanical collector who traveled in Texas]. Shall I send him some money, and how much; also what kind passes there.

Specimens coming in rapidly. I collected many myself and have as many sent me. Let me know how I can serve you, and believe me ever yours,

S. F. BAIRD.

Then again, to the accomplished collector, Arthur Schott, then at Eagle Pass, Texas:

SMITHSONIAN INSTITUTION, WASH., May 15, 1852.

My Dear Sir:

In a letter under date of Frontera of April 10 just received from Major Emory, he was kind enough to say that he had requested you to make some zoological collections on the Lower Rio Grande and forward them here,—or at least would do so. I was much pleased to learn of the stationing so accomplished a collector as yourself in this rich region, and doubt not that you will make the position tell greatly to the advantage of natural history. You, of course, need no especial instructions in regard to the mode of collecting the objects to be gathered. In so a virgin a field as the one you are now in, everything without a single exception is desirable.

My first favorites are as you well know, vertebrata, fishes and reptiles perhaps above all, mammals and birds, however scarcely behind. . . .

On April 2, 1853, he writes to Dr. Engelmann:

I think all the western parties will go provided with naturalists. There will be a most enormous mass of matter brought in this year from the west.

In March, 1857, he writes to Dr. F. Brandt, of St. Petersburg, relative to an exchange of specimens desired by the St. Petersburg Academy. After dealing with the matter of the exchange, Baird writes:

> In the enormous activity of the parties in connection or correspondence with the Smithsonian Institution, the number of species of North American Vertebrata has increased very largely in the last few years. Thus while Dr. Holbrook's work on our reptiles enumerated about 160 species of North American reptiles, we already possess nearly 400. Of fishes Dr. Girard described a few months ago about 50 species of Cyprinidæ alone from the region west of the Mississippi. We have nearly 200 species of birds not mentioned by Audubon, while of quadrupeds I have already determined about 60 species not given by Audubon and Bachman. It is here indeed that our collections show best, the addition having been at the rate of 1,000 per year for two years, not counting the small species in alcohol. The additional species embrace about 12 sorices, one *Urotrichus*, many Spermophiles, and squirrels, species of *Ursus*, *Felis*, *Cervus*, *Taxidea*, etc. Of every North American mammal we possess one or more skulls, except of *Enhydris marina*, *Capera montana*, *Gulo luscus* and *Ovibos moschatus;* the first and third of these we expect in a few months.[5]

No expedition was allowed to start out under government auspices without one of Baird's missionaries, as he called them, or, if that was impracticable, some one of the party being equipped with the apparatus for collecting and preserving specimens. Even John Howard Payne, the author of 'Home, Sweet Home,' when he went to take up his duties as consul, was supplied with copper tanks, alcohol and dip nets, with which he faithfully promised to secure a collection of Tunisian fish.

Every effort was made to enlist the services of occasional correspondents who wrote to the Smithsonian for information. A letter giving the particulars desired would perhaps have a postscript asking whether there were any Indian remains to be found in the locality where the correspondent lived, or whether there was any one who could be induced to make a collection of fish, reptiles, birds, etc. In a great many instances these letters bore important fruit, and any efforts made to comply with the requests would be received with such courteous expressions of approval, often backed up by Smithsonian reports or other literature bearing upon the subject, that the collector would before long become zealous in doing his part for so appreciative an institution. It was in this way that with the expenditure of very little money—for there was little money available for the purpose—the collections of the Smithsonian grew. It is probable that Baird's courteous manner toward all correspondents had a good deal to do with forming the custom which now prevails in the scientific departments in Washington, of promptly supplying every serious enquirer with information, and, if necessary, with publications. This useful and enlightened policy is

[5] The letter, as copied, is in a few places indistinct, but Dr. Gill has kindly interpreted the few difficult passages.

now thoroughly established in our government service, and is one of the most conspicuous marks of the superiority of our scientific bureaus over those of many nations. I have ventured to select two of Baird's letters to previously unknown correspondents as examples of his method. The first is to the sender of a hair-worm, that animal which most naturalists have learned to abhor because of the frequency with which they are called upon to explain its nature. Many of us, I fear, would have sent a curt reply, but not so Baird:

June 28, 1853.

Dear Sir:

The specimen you send is one of Gordius or hair-worm, a very interesting entozoon. The fact you mention of its crawling from the body of a cricket is very interesting as tending to settle the question whether the Gordius crawls into or out of the animal it infests. The association between the two has long been known, but every available fact bearing on the subject is of great value.

Yours truly,

S. F. Baird.

S. N. Sanford, Esq., Granville, Ohio.

Dr. Ridgway has elsewhere published (Smithsonian Report for 1888, p. 711) his first letter from Baird; here is the first letter to E. D. Cope:[6]

March 27, —58.

Dear Sir:

I was much pleased to receive your letter this morning and to see the minuteness of your knowledge of the Batrachia of Penna. I would be glad to know how extensive your herpetological studies have been, whether covering other branches than the Batrachia anoura, and whether you have gone at all into other classes.

In reference to your Hylodes . . . I can not without a reference to our specimens (at present somewhat inaccessible) decide. It appears, however, much like some dark varieties of the *Hyla pickeringii*. In a paper enclosed you will find description of some new frogs, one, *Helocœtes feriarum* hitherto only observed near Carlisle. I make the *Hylodes pickeringii* a *Hyla*, as I can not distinguish it generically. Of course not congeneric with *acris*. What do you mean by *Hylodes* . . . ? This may be the *feriarum*.

If your time is at your own disposal, it might be worth your while to visit Washington, and examine our Herpetological collections, which are of extraordinary richness. Our specimens of North American serpents number over 600 specimens and about 140 species.

It will always give me pleasure to hear from you and to render any assistance in my power to your studies.

Truly yours,

Spencer S. Baird.

E. D. Cope, care J. B. Garrett.

As the new material came in to the museum from all directions, it had to be taken care of and worked up. It is difficult to understand how Baird avoided being literally buried beneath the pile of accessions.

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[6] I omit the specific names which Cope appears to have given to the two frogs referred to, as they seem not to have been published.

In the earlier years there was very little help to be had, even of a purely mechanical sort, and he did most of the work with his own hands and with the aid of such friends as he could impress into the service. He was even obliged to pack up the Smithsonian exchanges; and for many years all his official letters were in his own hand. The first assistant curator of the embryo national museum was (speaking in wholly unofficial language) Mr. Solomon Brown, already mentioned. Appointed about two years after Baird took charge, for the purpose of assisting with the Smithsonian exchanges, this excellent colored man soon learned to skin animals and prepare skeletons, and was for nearly forty years Baird's right-hand man. If the assistance given by Brown lightened one side of the work, the other grew rapidly heavier, and for years it must have been a constant struggle for Baird and his few associates, such as Dr. Girard, to sort and label the specimens, and carry on the official correspondence. As one contemplates the old records, and remembers what was actually done and who there was to do it, it seems amazing that the mere routine work of the museum could be successfully carried on, and if ever a man had a valid excuse for not engaging in original research for lack of time surely that man was Baird. Original research, however, was the purposed end of all the accumulation. The materials obtained must be worked up and that with as little delay as possible. Baird was perfectly willing and glad to see this done by any competent person, but while securing cooperation wherever he could, he put his own shoulder to the wheel, and produced in rapid succession a series of works of the first importance.

This seemingly impossible achievement was due to the way he worked, after hours, during meals, and in fact to the limit of his capacity. Solomon Brown describes him to me as taking his coffee with one hand while he held his notes in the other; he could not stop even to eat. For nearly twenty years he kept this up; but after 1870 his executive duties having become very heavy, and the young men he had trained being well in harness, he ceased to engage in active research. That he felt obliged to do so, no naturalist can help regretting; for though it would be impossible to exaggerate the importance of his labors as head of the Smithsonian and Fish Commission, it is equally impossible to forget what we have lost in the way of illuminating investigations of our vertebrate fauna. It need not be considered an affront to those who came after him, to suggest that if Baird's time had been his own several groups would be in better order than they are to-day.

The task which Baird accomplished was, in brief, the putting in order of the mammals, birds, reptiles and amphibians of the North American continent, with the description of very numerous new species of these and of fishes. It will be well to give a brief summary of his labors:

Mammals.—The eighth volume of the *Pacific Railroad Reports,* published in 1857, is a large quarto of more than 800 pages, devoted to a complete revision of the mammals of North America, so far as the materials then available would permit. This work was much in advance of all others in the precision of the descriptions, the citation of localities and the care with which the synonymy was compiled. To this day, we have nothing that really takes its place. The matter of illustrations was not overlooked; I found among Baird's letters one dated January 24, 1852, addressed to d'Orbigny in Paris, asking how illustrations might best be made with a view to excellence and at the same time economy. What information d'Orbigny supplied I do not know, but the illustrations accompanying Baird's larger works were remarkable for their excellence, and highly creditable to the new museum.

Baird described in all sixty-three new mammals, of which forty-two are now considered valid, and twenty-one synonyms. I will confess that I was surprised at the large amount of synonymy; but it must be remembered that in the fifties large series for comparison, such as are available to-day, did not exist, while the descriptions of earlier writers were many of them imperfect. Nine genera and subgenera were proposed, of which seven are accepted to-day.

Birds.—I can not do better than quote the statements (Smithsonian Report for 1888, pp. 706–708) of Dr. Robert Ridgway, who more than any other man is to be regarded as Baird's successor in this field:

> With the publication, in 1858, of (the Pacific Railroad Report on The Birds of North America) a great quarto volume of more than one thousand pages, began what my distinguished colleague, Professor Coues, has fitly termed the 'Bairdian Period' of American ornithology—a period covering almost thirty years and characterized by an activity of ornithological research and rapidity of advancement without a parallel in the history of the science. Referring to this great work, in his 'Bibliographical Appendix' to 'Birds of the Colorado Valley' (p. 650), Professor Coues says: "It represents the most important single step ever taken in the progress of American ornithology in all that relates to the technicalities. The nomenclature is entirely remodeled from that of the immediately preceding Audubonian period, and for the first time brought abreast of the then existing aspect of the case. . . . The synonymy of the work is more extensive and elaborate and more reliable than any before presented; the compilation was almost entirely original, very few citations having been made at second-hand, and these being indicated by quotation-marks. The general text consists of diagnoses or descriptions of each species, with extended and elaborate criticisms, comparisons, and commentary. . . . The appearance of so great a work from the hands of a most methodical, learned, and sagacious naturalist, aided by two of the leading ornithologists of America (John Cassin and George N. Lawrence), exerted an influence perhaps stronger and more widely felt than that of any of its predecessors, Audubon's and

Wilson's not excepted, and marked an epoch in the history of American ornithology. . . . Such a monument of original research is likely to remain for an indefinite period a source of inspiration to lesser writers, while its authority as a work of reference will always endure."

Thus are graphically described the distinctive feature of what Mr. Leonhard Stejneger has truthfully termed the Bairdian School of ornithology, a school strikingly characterized by peculiar exactness in dealing with facts, conciseness in expressing deductions, and careful analysis of the subject in its various bearings;—methods so radically different from those of the older 'European School' that, as the esteemed member whom we have just named has already remarked, conclusions or arguments can be traced back to their source and thus properly weighed, whereas the latter affords no basis for analysis. In other words, as Mr. Stejneger has, in substance, said, the European School requires the investigator to accept an author's statements and conclusions on his personal responsibility alone, while the Bairdian furnishes him with tangible facts from which to take his deductions. . . . The distinctive features of the 'Bairdian school' were still further developed by the publication in 1864–66, of the 'Review of American Birds,' a work of unequaled merit, displaying in their perfection Professor Baird's wonderful powers of analysis and synthesis, so strongly combined in his treatment of difficult problems. Unfortunately for ornithology this work was but fairly begun, only a single volume (an octavo of 450 pages) being published. . . . I have it on good authority that no single work on American ornithology has made so profound an impression on European ornithologists as Professor Baird's 'Review,' and, by the same authority, I am permitted to state that he—a European by birth and rearing—became an American citizen through its influence.

Dr. D. S. Jordan writes, concerning Baird's methods:

He taught us to say, not that the birds from such and such a region show such and such peculiarities, but that 'I have the following specimens, which indicate the presence of certain peculiarities in the birds of certain regions. The first was taken on such a day of such a month, at such a place, by such a person, and is numbered so and so on the National Museum records.

This habit of exactness, introduced by Baird (who himself exhibited it, as we have seen, when still a boy), has been followed by most of our ornithologists, with the result that this subject has been brought to a remarkable degree of completeness. Let any one compare the current literature on birds with that on insects, and the immense influence and value of the Bairdian method will be at once apparent.

The 'Review of American Birds' described and classified a number of species from Costa Rica and adjacent countries; and Dr. Ridgway, who is now studying the birds of Costa Rica, with materials vastly more abundant and satisfactory than those possessed by Baird, tells me that he marvels at Baird's accuracy and insight. From Costa Rica alone, Dr. Ridgway has obtained from 3,000 to 3,500 birds, a greater number than Baird had from all middle America, including the West Indies; and yet Baird's work still stands, with very few modifications.

Baird described about 124 new species and subspecies of birds,[6] including a few which were published by others from his manuscripts. He established about 28 new genera and subgenera, most of which are now accepted and in current use. Quite a large number of the species are now reduced to subspecies, but this is explained by the fact that in Baird's day the trinomial system had not come into general use, and consequently binomials were used for birds which would now be considered to have less than full specific rank. It must also be remembered that the great series now available show intergrading forms which were not known fifty years ago. A certain number of synonyms were based on individual variations and immature states of plumage, and in one case a bird proved to be Asiatic, with a wrong locality. On the whole, judging by the modifications introduced by later authors, it appears that Baird's work on birds was of a higher grade than that on other groups; but it may be that this is largely to be explained by the relatively chaotic condition of the then-existing knowledge of the other classes, making the task of reducing them to order more difficult.

Batrachia.—In 1849, before he went to Washington, Baird published (*Jour. Acad. Nat. Sci. Philadelphia*) an important paper entitled 'Revision of the North American Tailed Batrachia.' In this work the nomenclature of the species was wholly revised, some new species were indicated, and the genus *Desmognathus* was established. This genus is now universally recognized, and Cope has made it the type of a distinct family, Desmognathidæ. Papers on Batrachia, containing descriptions of new species, and a few new genera, continued to be published until 1850, most of them in conjunction with Dr. Girard. After that date, in 1867, 1869 and 1889, a few species were published by Cope from Baird's manuscript. In all 42 species and varieties were published as new, and of these 26 are recognized as valid by Cope in his revision issued in 1889.

Reptiles.—Dr. W. H. Dall ('Smithsonian Report' for 1888) writes thus:

> Many of his herpetological papers were elaborate studies. One of the most important of the early memoirs was that on the reptiles of Stansbury's expedition to the valley of the Great Salt Lake, and another, that on those collected by the United States exploring expedition under Wilkes. The catalogue of North American Reptiles in the collection of the Smithsonian Institution is a classical work, serving to the present day as a text-book for students of herpetology. In 1859 appeared his great study of the reptiles collected by the parties engaged in the explorations for a Pacific Railroad, a monument of patient research and discriminating analysis. After this his contributions to the subject were mostly short papers or announcements of new or interesting facts.

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[6] Dr. Brown Goode (Bull. 20, U. S. N. M.) says 70, but searching the literature I have found a large number of additions.

Nearly all of this was the joint work of Baird and Girard, but Baird alone published a paper describing many new lizards in 1859. I find that 28 genera and about 120 species were introduced as new; of these, 11 genera and 34 species have been treated by Cope as synonyms.

Fishes.—Aside from the popular and economic work, Baird published descriptive works on fishes during the years 1853 to 1855, almost all the work being done jointly with Girard. Fifty-seven species and subspecies were proposed; 34 of these stand to-day as valid, according to Jordan and Evermann. Of six genera proposed as new, three stand as proposed, and a fourth as a subgenus. Most of the work relates to fresh-water fishes, but in 1854 Baird spent an eventful six weeks on the coasts of New Jersey and Long Island, and subsequently published a list of the marine species obtained. It is surprising to find that as the result of so brief an examination of such a supposedly well-known region it was possible to announce a new genus and seven new species. Two of the species have proved not valid, but the others are good, and no less than three of them have been made by Gill the types of new genera, making, with the genus described in the paper cited, four new genera as a result of the six weeks' work.

It must not be imagined that invertebrate zoology, botany, anthropology and other kindred subjects were neglected. Baird had a good general knowledge of all these, and, in particular, made himself familiar with the different workers all over the country, and sought their cooperation. Thus in his hands the museum actively prompted many branches of science, and a broad and stable foundation was laid. Dr. W. H. Dall, in *The Nation* of December 1, 1887, has eloquently described this phase of Baird's activities, and I can not do better than to quote his words:

> To make this policy (of wide cooperation) a success, such as it eventually became, required qualifications of no ordinary kind. Not only must the work of mediation be guided by the most advanced biological science of the time, but the individual intrusted with it must possess a spirit of impartial liberality, tempered by a sound discretion in business methods; a thorough knowledge and just estimate of men; an untiring patience to meet the peculiarities and caprices of the independent, and often one-sided specialists, whose cooperation was essential; a geniality to enlist the willing but unscientific colaborer; and an instant detection of humbug in every guise. Providentially for the future of natural science in this country, the need and the man met in the selection of Professor Baird. In qualifications for the work he stood preeminent—head and shoulders above any man of his time, and perhaps above all the scientific men of any time. He joined to a marvelous faculty for systmatizing business a capacity for study and continuous work only limited by his waking hours. His frank, genial and wholly unaffected manner put the scientist and the laboring man alike at ease. Always busy, he yet always seemed to have time for a friendly chat with every comer. His memory appeared an inexhaustible store-

house of facts on every subject where any desired datum lay ready to his hand.[7] He knew every specialist in the country. Not only did he hold amicable relations with scientists actually at work, but one might think there was not a schoolboy of extraordinary genius for bird's-nesting or fishing whom he could not lay his hands on . . . If he guided the activity of others as one would use impersonal agencies in the pursuance of a definite end, he was not less exacting with himself. He not only offered freely to others, sometimes constructive rivals, the raw material of research which he collected, but in many cases he put in the hands of those whom he thought worthy, his own more or less elaborated manuscripts, to use in their investigations, thus waiving his own priority in the field. His insistence on giving full credit to collaborators of every degree, both in publication and in records, labels, and reports, was proverbial. To the tyro treading with uncertain step the entrance ways of science he was ever cordial; always a friend, guide and helper. While Professor Henry lived, the affectionate loyalty of Baird to his venerable chief was an inspiration to those about him. . . .

It may be imagined that in his home life Professor Baird was altogether lovable, and we can not feel that we are laying sacrilegious hands upon the veil in saying that not the least of the benefits conferred upon American science was embodied in the influence which extended from that home upon a host of boyish students gathered from year to year under the brown towers of the Smithsonian Institution, slender as to their resources, half Bohemian as to their living, let loose with little restraint in that great disjointed village, the Washington of twenty years ago.

Dr. Jordan writes in the same strain, of—

the splendid benevolent personality that made Professor Baird the 'grandfather of us all,'—always interested in the scientific work of young men, and always ready to give them any help possible in that direction.

Every Sunday evening from eight onwards Baird's house was open to scientists young and old, and these informal receptions engendered a spirit of comradeship which must have done much to make lives happy and work run smoothly. The modern Cosmos Club, serviceable as it is, can not quite take the place of that nameless association of friendly spirits.

As an example of Baird's attitude toward young men, I am permitted to relate the circumstances of Dr. O. T. Mason's first meeting with him. The Smithsonian had received some Semitic inscriptions which had lain without being unpacked for some time, nobody taking much interest in them. Mr. Mason, hearing of their arrival, went to the museum to examine them; for he had already become much interested in Semitic ethnology, and expected to make it the chief study of his life. Professor Baird received him most cordially, and placing his hand on his shoulder said, 'these things have been waiting for you for six months.' So they were unpacked and set out where they could be seen; Professor Henry came in, and the three went over them carefully, the young

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[7] Solomon Brown said to me, that he never heard him say he forgot anything. —T. D. A. C.

man explaining them as well as he could in the light of his studies. When it was all over and Mr. Mason turned to go, Baird turned to him and said, 'Now I want you to give all this up.' While the young man almost gasped in astonishment, Baird continued: 'If you devote your life to such a subject as this, you will have to take the leavings of European workers. It will not be possible for you here in America to obtain the material for important researches; but—I give you the two Americas!' And Dr. Mason said to me, 'I was born again that day.' Before the young man left, Baird added an invitation to visit him at his house the following Friday; and for many years this visit was repeated on each successive Friday.

It would be impossible to select a better example of benevolent and helpful wisdom than that just described. Keen to pick out good men, wise in directing their activities, even in fields not specially his own, kindness itself in his dealings with them, it is no wonder that he gave an impetus to the study of natural history in this country which is not yet spent, and it may well be, will continue as a living influence for many generations. It was just the same in his dealings with his official subordinates, from the highest to the lowest. Every day he made the round of the departments, offering a suggestion or cheering word to each worker; and, as Dr. Ridgway tells me, there was no matter too small to excite his interest. He himself knew too much of the details of scientific research not to care about every step leading to the final results. It is just this sort of interest that distinguishes the true worker from the outsider; and fortunate it was for the growing museum that the chief could be thus a true comrade to each member of the staff.

This sympathetic attitude extended to every one about him. Mr. Pollock, who was a messenger under Baird, tells me that he was like a father to him. When Pollock had to go on some errand down town, if the day was hot, Baird would thoughtfully offer him his carriage; and if he saw him walking on the street, would stop and take him in. Baird's manners were absolutely democratic, and that without the least loss of dignity; he was thus an ideal American.

Dr. Ridgway tells me that Mrs. Ridgway often recalls the first time she ever saw Agassiz. It was in the great public hall of the Smithsonian, and Baird and Agassiz were walking side by side, each eating his lunch, while they chatted and examined the specimens. What a picture the scene would have made! Is there no artist who may yet attempt to do it justice?

When Professor Henry died, in 1878, it was inevitable that Baird should become his successor as head of the Smithsonian. Thus additional heavy cares were thrown upon his shoulders; and when, in 1882, the new building was completed, he had to superintend the reorganization of the museum, with an increased staff suited to its new opportunities. Dr. Dall told me the story of the origin of the National Museum building. The need was very great, but congress did not seem at all disposed to do anything. However, when the Centennial Exhibition was held at Philadelphia, money was loaned by the government to that city, and the congressional committee on appropriations was persuaded to agree that if the money was repaid a portion of it should go for a museum building. This was a qualified sort of promise, especially since many supposed that the money would never be seen again; but Baird was determined to make the best of it. He called together his associates, and explained the situation, adding that undoubtedly the final action of congress would depend very largely on the sort of exhibit they could make at the centennial. Under these circumstances, said he, it was for the staff to do their utmost, and he depended upon them to help him to produce an exhibit such as the people of America would be proud of. So they all worked day and night for six months or more, several of them without financial compensation, and when the exhibition was opened, every one was delighted with the result. The money was repaid by Philadelphia, the museum appropriation went through in 1879, and the building was ready for occupation in 1882. To-day it is as crowded as the old one was then, and happily another and better building is in course of erection. It is thus seen, that from first to last, it is no exaggeration to say that our National Museum owes its very existence to Baird. It is difficult to say what would be the condition of biological science in this country to-day had he not lived. It is at least probable that our credit as an enlightened and progressive nation would in this direction be very different, so greatly does a country depend upon its gifted sons!

As time went on, and the museum expanded, Baird was obliged to seek an assistant to share the administrative duties, and his choice fell upon Dr. George Brown Goode, who was already connected with the Fish Commission. In 1887 Dr. Goode was made assistant secretary of the Smithsonian Institution, in charge of the National Museum.

Baird had met Goode in 1872 on the Maine coast and had at once become greatly interested in him. Miss Baird writes:

> From the time of their first meeting, a warm personal attachment sprang up between them, which deepened every year up to the time of my father's death. From the time when Mr. Goode became associated with the museum work, my father's burdens in connection therewith greatly lessened, as year by year Mr. Goode's ability in that line developed. No cloud ever obscured their harmonious relations. I can recall but one difference between them, and that was on an occasion where some idea having been carried out in connection with the museum work in which they both felt a natural pride, each was so determined that all the credit belonged to the other, and argued so strongly, that they absolutely grew a little hot in discussing the matter! My father wished Mr. Goode to take all the credit, and Mr. Goode insisted that he had only developed what my father had directed.

My own opinion is that if my father had no other title to the gratitude of the scientific world, it would have cause to remember him with gratitude for having afforded the facilities for the development of Mr. Goode's genius, which, however, would have made itself known in time without aid.

The attention of the public had been called, at the beginning of the seventies, to the increasing scarcity of food fishes on our coasts and in our rivers. By a joint resolution of congress, approved February 9, 1871, President Grant was authorized and required to appoint a person of proved scientific and practical acquaintance with the fishes of the coast to be Commissioner of Fish and Fisheries, with the duty to promote investigation into the causes of diminution, if any, in number of the food-fishes of the coast and the lakes of the United States, and to report whether any and what protective, prohibitory, or precautionary measures should be adopted. The one man to whom the above description was applicable was of course Baird, and he was requested to assume charge of the work. This he did, and not content with merely carrying out the instructions given, he proceeded to build up a great national institution for the study of fishes in their economic and scientific relations, proving to the world that the fish-supply was capable of being largely controlled and increased, and the available food of mankind thereby increased enormously. Without going into details, the growth and work of the Fish Commission under Baird can be best described in the words of Dr. Dall—

No more emphatic object-lesson of the vital relations existing between research, as such, and the promotion of the material interests of mankind has ever been furnished to the so-called 'practical man' than that afforded by the work of the United States Fish Commission as directed by Professor Baird. Whether germane to the subject of scientific research or not, the most narrow specialist can hardly begrudge an allusion to the grandeur of the methods by which the food supply of a nation was provided, hundreds of rivers stocked with fish, and the very depths of the ocean repopulated. Typically American we may call them in their audacity and their success. The fishery boards of foreign countries, first quietly indifferent, then loudly incredulous, in due time became interested inquirers and enthusiastic followers. In a few years we may fairly expect to see the food supply of the entire civilized world materially increased, with all the benefits which that implies, and this result will in the main be owing to the unremunerated and devoted exertions of Spencer F. Baird.

Baird's writings, according to Dr. Goode's bibliography, number 1,063, this including a few republications. A very large number of titles refer to popular articles, contributed in the main to *Harper's Magazine* and *Harper's Weekly*, and republished in the *Annual Record of Science and Industry*. These articles called attention to many phases of scientific activity, usually with critical comment, and must have been important instruments of public education. There were also numerous short contributions to *Forest and Stream,* and the *Chicago Field,* relating to the popular phases of the fish work.

Baird's incessant labor at length began to tell upon his health. Unwilling to rest, he was finally informed by his medical adviser that complete relaxation was imperative, and he reluctantly accepted the decision. Professor Langley had taken charge of the Smithsonian, and the well-beloved and trusted Dr. Goode was caring for the National Museum; it seemed that the well-earned rest might be taken in peace. It was too late, however, and realizing that the end was near, he permitted himself to be taken to Wood's Holl, to the seaside laboratory of the Fish Commission. We may fitly close the story in the words of Major Powell:

> For many long months he contemplated the day of parting. Labor that knew no rest, responsibility that was never lifted from his shoulders, too soon brought his life to an end. In the summer of the past year (1887) he returned to his work by the seaside, that he might die in its midst. There at Wood's Hole he had created the greatest biologic laboratory of the world; and in that laboratory, with the best results of his life-work all about him, he calmly and philosophically waited for the time of times. Three days before he died he asked to be placed in a chair provided with wheels. On this he was moved around the pier, past the vessels which he had built for research, and through the laboratory, where many men were at work at their biologic investigations. For every one he had a word of good cheer, though he knew it was the last. At the same time, along the pier and through the laboratory, a little child was wheeled. 'We are rivals,' he said, 'but I think that I am the bigger baby.' In this supreme hour he was playing with a child. Then he was carried to his chamber, where he soon became insensible and remained so until he was no more.

He died on August 19, 1887.

INTERCOLLEGIATE CONTESTS

By Professsor JOHN J. STEVENSON,
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THIRTY years ago, student organizations in the ordinary college were few and on a modest scale, laying no serious burden of any sort on the members. All were purely voluntary and members alone shared in either expense or advantage. Gymnastics were recognized officially in few institutions and such athletic clubs as did exist were for amusement. College boys, like other boys, were not all stalwart, some were even 'slab-chested'; but the testimony of alumni catalogues proves that their tenacity to life was such that on the average they were very good insurance risks.

Conditions in many respects have undergone change. A college, whether the students be scores or thousands in number, seems compelled to maintain one or more teams in athletics, with frequently a glee club in addition—not in any sense for amusement or for improvement, but for contests with similar organizations in other colleges. The expense is serious, but the active members are not expected to defray it, as they 'do the work.' Others must pay the bills, either directly or indirectly, under penalty of being regarded as 'chumps' without college spirit. If means be available professional coaches are always employed for athletic teams and glee clubs. The selected few in the organizations enter upon their work as a business and undergo severe training, which requires close attention and much time—and this not during vacation periods, but during the college year, when study is supposed to demand most of the student's energy. The total money expenditure on these associations must be something stupendous; in some institutions, clamoring for funds, the amount annually handled by teams and other organizations is almost enough to endow a professorship.

These semi-professional organizations, playing or singing for 'gate money,' have damaged the morals of college students, even the morale of the colleges themselves. Heads of teams keep close watch of secondary schools, not in search of brilliant students, but in search of boys who have made 'records,' and the entrance of such boys brings joy to the student body. New York is only too familiar with the scenes of debauchery which have followed great contests, as gambling has preceded and accompanied them. It has been charged that college authorities wink at flagrant evasions of laws governing amateur contests and permit 'ringers' to appear as their representatives; but this charge should not be made lightly, for those in responsible place are usually the last to hear of irregularities. At the same time, one who reads the sporting page of a great daily paper and considers the pettifogging disputes of committees representing contesting institutions can not resist an uneasy feeling that the lowering of morale has not stopped with the student body.

College students are quite as willing to yield to temptation as are other young men; some of them indeed, like other men, are ready to go somewhat out of their way to fall into temptation. This much must be conceded; yet no one would regard that as a ground for opening a subway tavern on the campus or for licensing a high-grade gambling outfit in the library building. Students, like others, are apt to show decided disinclination for the work in hand; yet no college official would announce that as justification for encouragement to neglect study. But to encourage membership in college organizations of to-day is to encourage neglect of study. The active members are required to maintain respectable standing in class-room work, though no ordinary man can do this, if the college course be what it is supposed to be, without interfering with his duties, which students in many places evidently think more important than studies. And the college authorities seem to agree with the students, for they permit glee clubs to sing at evening concerts near and far away; they permit teams to undergo training and to absent themselves—all in such fashion that the men must fall behind in their work, if the work be what it purports to be. Yet these men get through and all the students know it.

The incongruity of the conditions affords constant play for newspaper wit, and colleges are regarded popularly as agglomerations of associations with a teaching annex. Colleges receive great attention from the newspapers on pages devoted to sporting news, very little elsewhere except in columns devoted to wit and humor. The coach is much more important than the professor of Latin.

It is impossible for college authorities to escape responsibility for the conditions and all the evils connected with them: any attempt to evade that responsibility is, to say the least, unmanly. Intercollegiate contests are recognized as part of collegiate operations: the students' control is nominal, the institution's control is absolute. Fields for athletic sports have been provided at great cost and they are well equipped with 'grand stand' and 'bleachers': the gymnasium with all its paraphernalia for gymnastic contests is, at times, almost as imposing as the library building; and the excellence of the equipment is set forth duly in official publications. Qualifications for active participation in the organizations are determined by the authorities who supervise the schedules of engagements and in some instances even the pecuniary affairs.

One may wonder why these college authorities, with power to stop, consent to continuance of the conditions. Many reasons are given in justification, most of them purely evasive and absurd; but there is one argument which is regarded as final and unanswerable. These contests arouse college spirit among the students; they advertise the college; they awake enthusiasm among the alumni; an important contest receives elaborate notice on the sporting page which everybody reads, and the community learns that the college exists; a glee club swings around the circle of a score of towns and proves better for advertising than if the virtues of the college were blazoned on even Gibson posters adorning fifty miles of fences. No one was surprised to read a telegram one day in November last to the effect that the Association of Presidents of State Universities at its Washington meeting tabled 'a resolution—deploring the brutality, and waste of time resulting from the game [football] as now played.'

It may be said that, as a rule, parents are not only willing, but are also gratified, to find their sons prominent in these organizations; but the vast majority of parents know nothing about college work and they confide in the wisdom as well as in the integrity of the men to whom they have entrusted the education of their sons. There is no room for casuistry here. If a school of business should encourage students to glorify it by contests which might lead to paralysis of the right hand, or if a divinity school should provide opportunities for contests which might induce permanent injury to the voice, the press would comment at least unfavorably upon the wisdom of those in control. But technical schools, preparing men to be civil, mechanical or mining engineers, encourage their students to take part in football, though the authorities know that knees, ankles, shoulders and back are likely to be so injured as to handicap the man throughout life. This is no merely academic proposition, as is evident from the list of injuries reported officially in two institutions at the close of the 1905 season.

The recent discussions awakened by the increasing brutality of football tend to divert attention from other and far more important matters. Immense sums of money have been given for educational purposes, many times by men unfamiliar with college conditions but anxious to advance the good of their fellows in the most effective way. One can hardly imagine that they expected their money to be employed in the encouragement of semi-professional organizations and in developing the shirking propensities of young men. One may well ask if colleges are acting in good faith toward their benefactors, toward parents as well as toward the students themselves.

The college course covers four years and much is said about the necessity for shortening it; the technical courses cover four years and much is said about the necessity of lengthening them. The writer believes that the college course should cover four years and that four years is a barely sufficient period for a proper technical course. But what are the conditions? As has been said, the active members of organizations are required to maintain respectable standing as students; during football season, a member of the team can do very little studying, as he has no time; even if he should have time he could have no disposition. His attention is distracted too often by the necessity of nursing bruises, of repairing other damages or of seeking rest for a time in the hospital. Other organizations do not require similar physical racking but equal waste in energy and loss in time causing similar unfitness for study. In large institutions comparatively few individuals suffer in this way, as there is no duplication on teams, but in a small college the same men are on several lists, so that the football hero of November may be a brilliant star in the glee club during winter and a mainstay of baseball in spring. Yet with few exceptions these men make good all their losses and gain their degrees in technical schools quite as well as in colleges. Far be it from the writer to say that the course has been adjusted deliberately to meet the necessities of these champions; but the fact remains that these men to whom study, in the true sense of the word, is practically out of the question during a considerable part of the college year, do succeed in completing the course. It is certain that neither the college course nor that of the technical school requires four years of study for its completion—though it ought to. And it may be remarked parenthetically that this is equally true of the constantly lengthening period demanded by secondary schools for preparation, since in those schools also the advertising value of interscholastic contest is appreciated to its full extent. The requirements for entrance to college courses have been increased so little during the last forty years that a city lad of ordinary ability ought to be ready to enter college by the time he is sixteen years old.

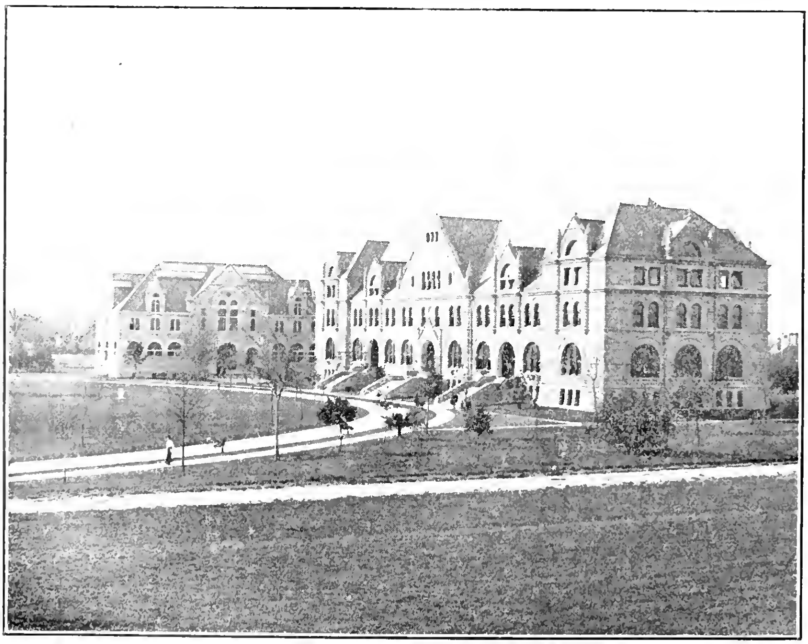
If intercollegiate contests are to be continued as a part of college operations, simple honesty requires that a change be made in the arrangement of studies. Men who wish merely to learn, who have no ambition to shine in athletics, glee clubs or other organizations, should not be compelled to hang around college or technical school for four years. They should have the opportunity to finish their work in proper season and to avoid the loss of a year or of a year and a half at the critical period of life. The college circulars should be very clear in explaining the conditions, so that parents might be able at the outset to decide in which division to place their sons. Those who are willing to have their sons 'get through' as well as those who desire to have their sons receive a generous intellectual training would make their arrangements intelligently and there would be no longer room for complaint.

THE PROGRESS OF SCIENCE.

THE CONVOCATION WEEK MEETINGS OF SCIENTIFIC SOCIETIES

The American Association for the Advancement of Science meets at New Orleans from December 29 to January 4. The place of meeting is somewhat remote from the main centers of scientific activity, and the attendance will scarcely be as large as when the association meets in one of the sea-board cities. But those who are able to attend will find the meeting of more than usual interest. A particularly good and unexpectedly large meeting of the American Economic and Historical Associations was recently held at New Orleans, and one of the pleasantest meetings of the American Association was held several years since at Denver. When the surroundings are new to many of the members—and New Orleans has many of the attractions of a foreign city—the meeting is likely to assume a more individual character and to profit both from the unusual conditions and from the greater intimacy into which the members are brought with one another.

There is of course no danger from yellow fever at New Orleans; indeed the complete suppression of the recent epidemic by scientific means will add to the interest of the meeting. This has been made the occasion for a special discussion on yellow fever and other insect-borne diseases, which will be taken part in by a number of those who have contributed in important measure to our knowledge of the causes and remedies of these diseases. The southeastern and central passenger associations have offered a rate of one fare and twenty-five cents to New Orleans, which is more favorable than



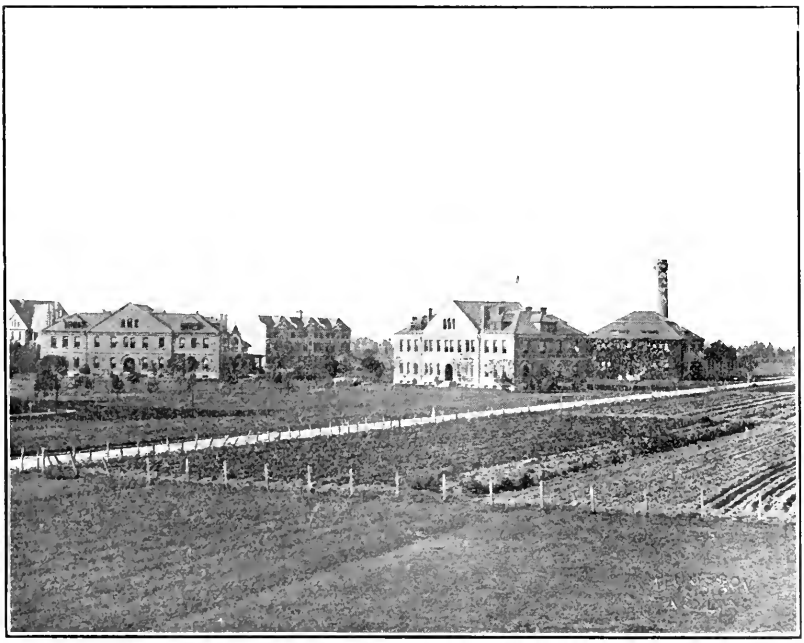
Campus of the

the association has hitherto been able to obtain and should lead many members to take advantage of it. New Orleans can be reached from New York City by a journey of two nights and one day.

The first general session of the association convenes on the morning of Friday, December 29, when the members will be welcomed by the governor of the state, the mayor of the city and the president of Tulane University, to whom the president-elect, Professor C. M. Woodward, of Washington University, will reply. The retiring president, Professor G. W. Farlow, of Harvard University, will give an address in the evening on 'The popular conception of the scientific man at the present day.' Each of the ten sections of the association will offer an attractive scientific program, and arrangements have been made for numerous excursions, receptions and the like. Most of the meetings will be held at the Tulane University, an institution which in recent years has made great progress, which on the material side is shown by the illustrations here given.

The American Chemical Society, the Botanical Society of America and several other scientific societies meet in affiliation with the association, but there is this year a wide scattering of the societies which last year met together in Philadelphia in convocation week. The American Society of Naturalists, with the special societies devoted to zoology, botany, physiology, bacteriology and anatomy, meet together at the University of Michigan; the societies devoted to mathematics, astronomy, physics and paleontology meet in New York City; the students of philosophy and psychology go to Harvard University, where a new building to be devoted to these subjects is to be formally opened; the anthropologists meet in Ithaca, and the geologists at Ottawa.

There are certain attractions in a meeting of scientific men having common interests at a small university town that a large assemblage in a city



TULANE UNIVERSITY.

MEDICAL DEPARTMENT OF THE TULANE UNIVERSITY.

does not possess. There are, however, also certain disadvantages. For example, many scientific men this year are in doubt as to which of the meetings they should attend, and there is no opportunity for the assembling of a general council of scientific men and for the numerous committee meetings

THE H. SOPHIE NEWCOMB COLLEGE FOR WOMEN OF THE TULANE UNIVERSITY.

which can to advantage take place during convocation week. Neither can the societies singly exert the influence on the public and on public affairs which they can hope to gain by united effort. The best solution of the problem would probably be for the American Association and all our scientific societies to meet together in one of our larger cities in the winter and to arrange for a smaller and less technical meeting at one of the university towns in the summer; and, so far as possible, for the societies that wish to hold separate meetings to call them at times that will not interfere with the great convocation week meetings.

AWARD OF THE NOBEL PRIZES

On December 10, the anniversary of the death of Alfred Nobel, the great prizes established by his will were awarded for the fifth time. The award for the promotion of peace to the Austrian Baroness von Suttner for her novel, entitled 'Die Waffen nieder,' and that to the great Polish novelist, Henryk Sienckiewicz, for literary work in an idealistic direction, do not fall within the immediate scope of this journal. The prize in physiology and medicine goes to Professor Robert Koch, that in physics to Professor Philipp Lenard, and that in chemistry to Professor Adolf von Baeyer.

Each of the recipients has a worldwide reputation for scientific research and discovery. Dr. Koch has the great distinction of having discovered the bacilli of tuberculosis and of cholera. His tuberculin has failed as a remedy, but has proved of great value in diagnosis. His researches on malaria, rinderpest and various tropical diseases have been contributions of vast importance for the study and cure of disease. Dr. Koch does not hold a university position, and like Dr. Behring, to whom a Nobel prize was awarded in 1901, he earns money by his discoveries. They have been criticized for this, but it may be that the greatest advances in science will come when investigators are paid directly for their work instead of indirectly as at present. Dr. Koch was born in Clausthal in 1843; he studied at Göttingen and carried on his researches for some years as a practising physician in small towns. In 1880 he became an officer of the Imperial Bureau of Health at Berlin, and in 1885 was appointed director of the Berlin Laboratory of Hygiene and professor in the university. He has, however, been chiefly engaged in expeditions to tropical countries under the auspices of the German and other governments, and is just now returning to Berlin from South Africa.

Professor Lenard, of Kiel, is distinguished for the discovery of the rays that bear his name, which was an important step forward in the direction of research which has become dominant in recent physics, the phenomena of radiation and the theories of the constitution of matter, with which the names of Röntgen, Becquerel and the Curies, who have already received Nobel prizes, are associated, and to which Thomson, Rutherford and Crookes have contributed in equal measure. Lenard was born 1862, studied at Heidelberg and at Berlin, and has filled teaching positions in Bonn, Breslau Heidelberg and Kiel. He has accomplished much valuable work in addition to his release of the cathode rays from the Crookes tubes, but he is scarcely the peer of Lord Kelvin or Professor J. J. Thomson, neither of whom has received a Nobel prize.

Baron von Baeyer, of Munich, has made contributions of great importance to organic and industrial chemistry. His work on the carbon compounds is of much theoretical interest, but he is most widely celebrated for the discovery of aniline dyes and the artificial production of indigo. Professor von Baeyer celebrated his seventieth birthday on October 31. Born in Berlin, he studied there, and at Heidelberg and Geneva. He qualified as *Dozent* at Berlin in 1860 and became full professor of chemistry at the newly-organized University of Strasburg in 1872, succeeding Liebig at Munich in 1875.

ALFRED NOBEL.

He was made a noble with hereditary transmission of the title in 1885. His great work in synthetic chemistry entitles him to belong to the group of those who have already received Nobel prizes in chemistry—van't Hoff, Fischer, Arrhenius and Ramsay.

These Nobel prizes, each of the value of about $40,000, were established by the will of Alfred Nobel, who died in 1896. Nobel was born in Stockholm; he studied in St. Petersberg, and began to assist in his father's engineering works, but soon took up the study of high explosives. In 1864 he took out a patent for dynamite, obtained by incorporating nitro-glycerine with some porous substance. Later he invented ballistite, a nitroglycerine smokeless powder, but his claim that the patent covered cordite was disallowed by the courts after a lawsuit against the British government. From the manufacture of dynamite and other explosives at his works in Ayrshire and from developing the Baku oil-fields, he

R. Koch

amassed the great fortune with which he founded the prizes that bear his name.

THE DETERMINATION OF SEX

At the New Haven meeting of the National Academy of Sciences, held in November, Professor Edmund B. Wilson presented the results of observations that constitute an important step towards the solution of the long standing problem of the determination of sex. These observations demonstrate that in several genera of insects, belonging to the Hemiptera, sex is predetermined at least as early as the fertilized egg, and may be traced to antecedent conditions that preexist in the germ-cells before their union. In most of the species the spermatozoa are predetermined as male-producing and female-producing forms, equal in number, that differ visibly in the constitution of the nuclei. The differences between the two classes do not appear in the mature spermatozoa but are plainly apparent in the process of their formation. In some cases the female-producing spermatozoa contain one more chromosome than the male-producing ones, in others both classes have the same number of chromosomes but one of them is much smaller in the male-producing class. These initial differences in the spermatozoa lead to corresponding differences in the nuclei of the two sexes, the cells of females either containing one more chromosome than those of males or showing a greater quantity of chromatin in the greater size of one of the chromosomes. The sex of the individual may, therefore, be recognized in these cases by simple inspection of the dividing cells.

Although these visible differences are of wide occurrence in these insects they are not always present, for in one of the genera male-producing and female-producing spermatozoa can not be distinguished by the eye and the nuclei of the two sexes have the same appearance. This case is, however, connected by almost insensible gradations with those in which the differences are plainly apparent, and it is hardly possible to doubt that sex-production conforms to the same type throughout the series. It is, therefore, not improbable that two classes of spermatozoa, predetermined as male-producing and female-producing forms, may exist in animals generally, even though they are not, as a rule, visibly distinguishable.

It is not yet known whether this also applies to the eggs before fertilization. In these insects there is no visible indication of such a predetermination, but several cases are known in which the eggs are of two sizes before fertilization, the larger ones producing females and the smaller ones males. It is, therefore, possible that in animals generally, both eggs and spermatozoa may be predetermined as male-producing and female-producing before their union. In any case these observations bring a strong support to the view, which has rapidly gained ground in recent years, that sex is predetermined at least as early as the fertilized egg, though they do not exclude the possibility that in some cases sex may be affected by conditions acting upon the embryo subsequent to fertilization. It does not yet clearly appear how these new results can be applied to an explanation of sex-production in parthenogenesis, in hermaphrodites and in such cases as that of the bee where all the fertilized eggs are of the same sex. A new basis has, however, been gained for the investigation of these questions, and also for an interpretation of sex-production in accordance with the Mendelian principles of heredity, the probability of which has been urged by Castle, Bateson and other writers.

TWO GERMAN DIRECTORIES

There appeared in November the fifteenth annual edition of 'Minerva' and a little earlier a German 'Wer Ist's.' The former of these works is well known to scholars throughout the world. It is an invaluable address book containing the names and chairs of the professors in the universities and other institutions of higher education of all countries, the officers of libraries, museums, academies, etc., and much information in regard to the organization of these institutions. The editing is a model of careful exactness; it requires some search to find a misspelled name among the 40,000 in the book. The work is brought out with unusual promptness. It appeared early in November and contains changes up to October. Each year a portrait of an eminent scholar is given as a frontispiece. This year Dr. Sophus Müller, director of the National Museum at Copenhagen was selected, and the portrait is here reproduced.

There is of course room for criticism even of this excellent book. If an editor could be found in each country who would revise the data with a view to uniformity, some substantial gain would result. The data obtained from the separate institutions are not always comparable. Thus for some American

Dr. Sophus Müller.

institutions both professors and instructors are included, for others the professors only. In the German universities the names are arranged under faculties by seniority, but it is impossible to discover what plan has been followed in some American institutions. Professor Wolcott Gibbs, the dean of Harvard professors and of American men of science, and Professor Charles Eliot Norton are omitted from the Harvard list, though emeritus professors are included in other institutions. Sometimes the names are given in full and sometimes they are abbreviated without any apparent system, the names not being printed as they should be written—Th. may be used for T, Will. for William or W. etc. The inclusion of institutions is not consistent. Thus the Philadelphia High School is admitted, but not the College of the City of New York. The Armour and Rensselaer Technological Institutes are admitted, but not the Stevens and Worcester Institutes. The Philadelphia Zoological Garden and the St. Louis Botanical Garden are admitted, but not the similar institutions of New York, etc. The statistics are not uniform. Thus Columbia is given as the largest American university, followed by Chicago and California. Cairo, Budapest, Moscow, Madrid and Naples are in the list of the nine largest universities of the world.

A German 'Who's Who' will be of much service both there and here. A French 'Dictionnaire des Contemporains,' which is unfortunately now twelve years out of date has been issued, but no similar book had been compiled for Germany. We regret, however, to say that 'Wer Ist's' (H. A. L. Degener, Leipzig), is an example of bad editing. The introduction is amusingly pretentious. We are told that the work will contribute to 'einer grossen deutschen Friedensweltmacht' and much more to the same effect. Such a book should not attempt to be international in character. It is impossible to guess how the American names were selected. 'Rooseveld' indeed will be found, who organized 'Rauhen Reiter' and wrote about 'das rastlose Leben,' but not Mr. Cleveland. 'Murray N. Butler, L.L.D.,' of Columbia University, is there, but not President Eliot, of Harvard University. Numerous Americans are included for no evident reason, but not men such as Mr. Carl Schurz, Mr. Andrew D. White or Mr. Charlemagne Tower, whose relations with Germany are intimate. In one short sketch there are fourteen typographical errors. When the editor says that the subjects of the foreign sketches are contemporaries 'über die wir so gut wie Nichts wissen,' it may be assumed that the editorial 'we' was not intended, but it would have a certain appropriateness. The German biographies are of course much better, though by no means free from errors, and there are many omissions. Thus Professor Lenard who has just now received a Nobel prize is not included. The book will doubtless be improved in subsequent editions; but even now it is decidedly useful to those who have relations with the public men and scholars of Germany.

SCIENTIFIC ITEMS.

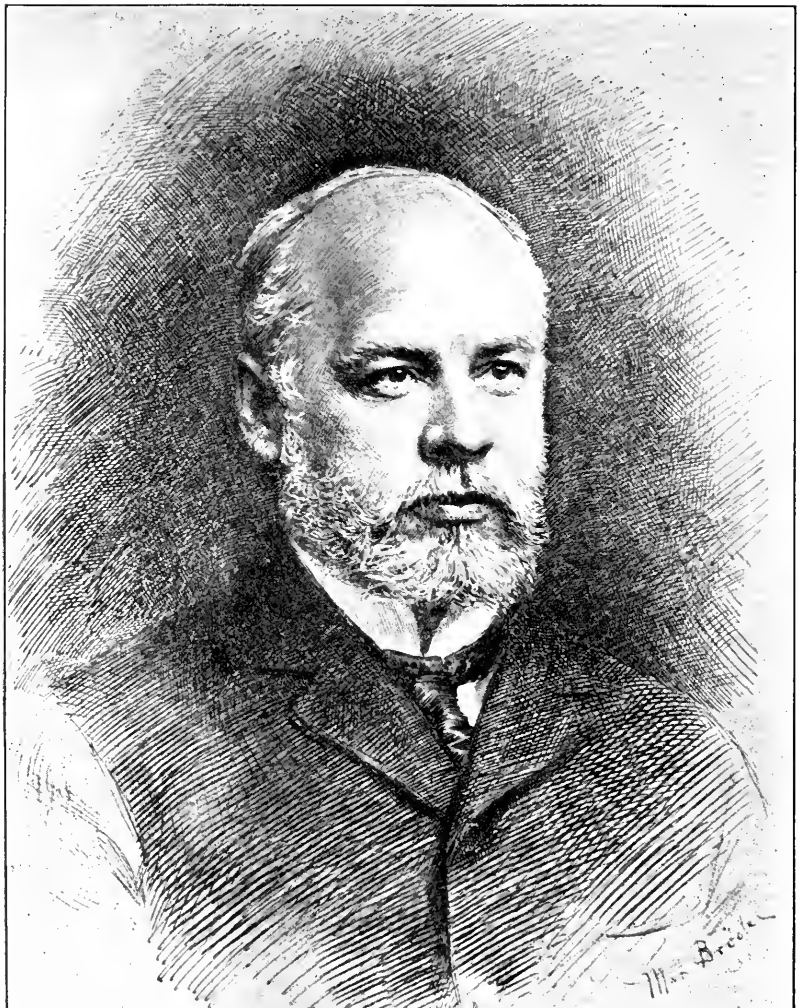
We regret to record the deaths of Professor Albert von Köllicker, the eminent anatomist and zoologist; of Sir John Scott Burdon-Sanderson, formerly Waynefiete professor of physiology and regius professor of medicine at Oxford; of Dr. Gustave Dewalque, formerly professor of geology at Liège, and of Dr. E. Oustalet, professor of zoology in the Natural History Museum of Paris.

Dr. Henry S. Pritchett has resigned the presidency of the Massachusetts Institute of Technology to become president of the Carnegie Foundation for pensioning college professors. —Dr. Friedjof Nansen will shortly go to London as minister from Norway.—Dr. George H. Darwin, F.R.S., Plumian professor of astronomy and experimental philosophy at Cambridge, has been knighted by King Edward.—Lord Rayleigh has been elected president of the Royal Society in succession to Sir William Huggins.

The statue of Benjamin Silliman has been removed from its site on the old campus of Yale University, near the library, to a place between the Sloan and Kent laboratories.—A bust of the late Professor M. Nencki has been unveiled in the chemical department of the Institute of Experimental Medicine, St. Petersburg.—A memorial to Theodore Schwamm, regarded as the originator of the cell theory, is to be erected in his native birthplace, Reuss.

The Hayden memorial gold medal of the Academy of Natural Sciences of Philadelphia, has been voted to Dr. Charles D. Walcott, director of the United States Geological Survey.—Medals were awarded by the recent Congress of Tuberculosis to Drs. Koch, of Berlin; Brouardel, of Paris; Bang, of Copenhagen; Biggs, of New York; Broadbent, of London; and von Schroetter, of Vienna.—The French Academy of Moral and Political Sciences has decided to award the François-Joseph Audiffred prize, of the value of $3,000, which is given in recompense of the most beautiful and greatest acts of self-devotion of whatever kind they may be, to Professor Calmette, director of the Pasteur Institute at Lille.

The following is a list of those to whom the Royal Society has this year awarded medals: The Copley medal to Professor Dmitri Ivanovitch Mendeléef, of St. Petersburg, for his contributions to chemical and physical science; A Royal medal to Professor John Henry Poynting, F.R.S., for his researches in physical science, especially in connection with the constant of gravitation and the theories of electrodynamics and radiation; A Royal medal to Professor Charles Scott Sherrington, F.R.S., for his researches on the central nervous system, especially in relation to reflex action; the Davy medal to Professor Albert Ladenburg, of Breslau, for his researches in organic chemistry, especially in connection with the synthesis of natural alkaloids; the Hughes medal to Professor Augusto Righi, of Bologna, on the ground of his experimental researches in electrical science.



William H. Welch.

THE
POPULAR SCIENCE
MONTHLY.

FEBRUARY, 1906.

THE PASSING OF CHINA'S ANCIENT SYSTEM OF LITERARY EXAMINATIONS.

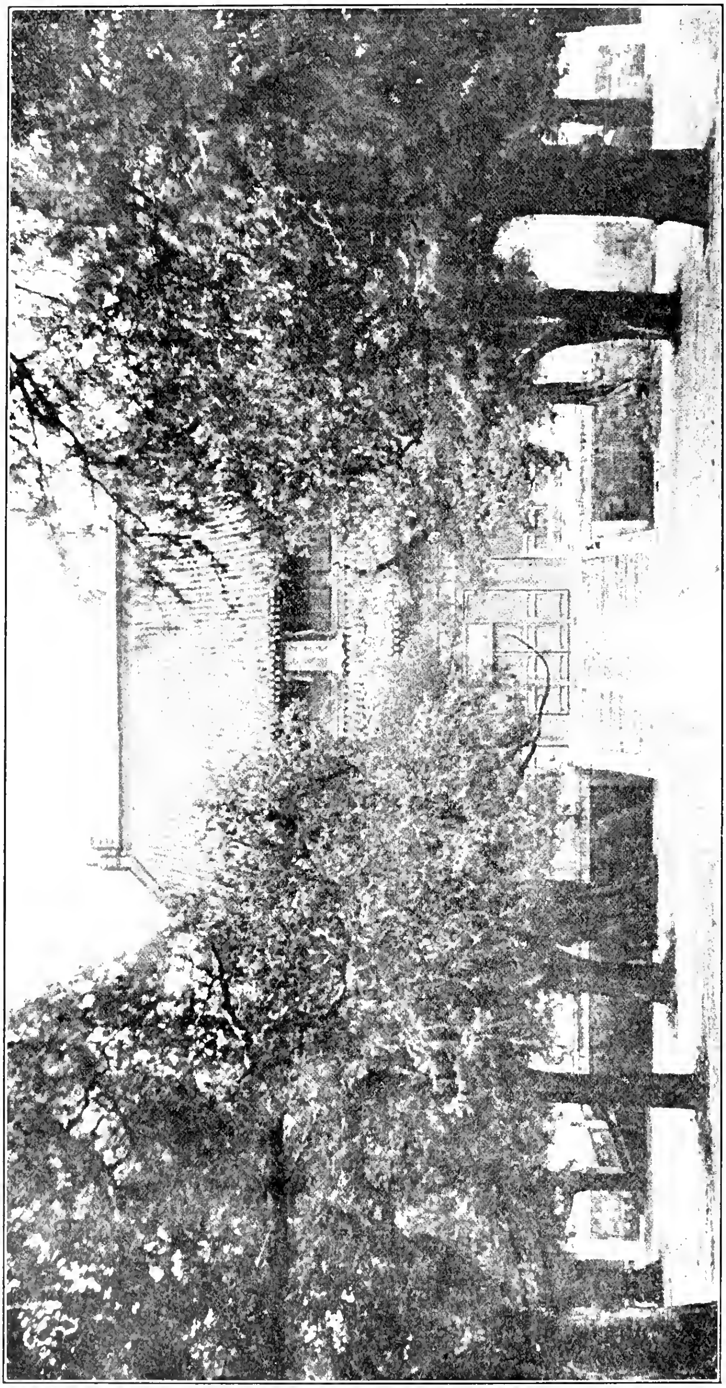
BY CHARLES KEYSER EDMUNDS, Ph.D.,
CANTON CHRISTIAN COLLEGE.

IN a previous paper we reviewed the subject matter of Chinese education and recalled the fact that there is not, and practically never was, a school system in China, though a characteristic method of instruction has prevailed for ages, which by reason of its imitative and servile nature has repressed originality and drilled the nation into a slavish adherence to venerated usage and dictation without supplying real or useful knowledge.

Without doubt, the heart of China's nationhood thus far has been her system of literary examinations, and the place given to scholars in all phases of the nation's life combined with the inefficient character of the learning they possessed has been the primary cause of the nation's peculiar course and its present weak condition, from which happily it is awakening through the adjustment of education to the real needs of life.

The darkest days of the west, when Europe was wrapped in the ignorance and degradation of the middle ages, were the brightest days in the east. China was then probably the most civilized country on earth and exercised a humanizing influence on all surrounding states. Had she kept the lead she then held, instead of presenting to the world as she now does the most remarkable case of arrested development within historic time, China would be in fact what for so many centuries she has so fondly but mistakenly considered herself to be, the mightiest of the mighty powers.

It is indeed striking in a country which can count back to schools more ancient than those of any other living race that the scholars of



THE CONFUCIAN TEMPLE, PEKING, in the Court of which the names of graduates have been carved on stone tablets, for the past 600 years.

the realm should of all the learned men of the age be the most ignorant of essential and practical truths; that a nation which possessed the most elaborate system of civil service examinations should be served by officials at least as corrupt and as inefficient as those of any other great nation; that a government which made literary attainment a condition of office-holding was content to develop an imposing superstructure of examinations and rewards and neglected to lay the foundation for such in a system of common schools.

The method of instruction which has prevailed wherever there have been any schools at all—a method not only very ancient, but proceeding from, and at the same time in great part responsible for, those characteristics which mark the Chinese under every variety of physical condition—has been of a hard and unyielding nature, and has caused enough wasted energy during the last seven hundred years to have sufficed for more than ten thousand years of true education, and this has made China what she is to-day. While the government has fostered culture by testing attainments and granting rewards, thus affording an efficient stimulus on a large scale and constituting a regulated state patronage of letters according to which the reward of literary merit was a law of the empire and a right of the people, it is also true that up to the present time Chinese education has been entirely political in aim and has been valued merely as a means of securing the repose of the state, and, as soon as a sufficient supply of disciplined agents has been at hand, the enlightenment of the people has lacked governmental regard.

But such a state of affairs can not longer endure—the wall is breaking down; and it is the purpose of the present paper, without attempting to characterize further this old method of instruction or to point out its gradual and general renovation under the influence of Western thought and life and especially of the christian schools throughout the land, to call attention to the latest and perhaps most important step in the line of advance, *viz.,* the practically complete abolition of the ancient system of literary examinations and degrees given to advanced students in Chinese history, philosophy and poetry.

Perhaps the most accomplished of China's long line of monarchs was Li Shi-min, second emperor of the Tang Dynasty (618–908 A. D.). 'Famed alike for his wisdom and nobleness, his conquests and good government, his temperance, cultivated tastes and patronage of literary men,' he ranks with Marcus Aurelius, or with Charlemagne, who came to his throne in the next century. Under his direction great pains were taken to preserve the records of former days and to draw up full annals of the recent dynasties. He published a complete and accurate edition of all the classics under the supervision of the most learned men of the realm, and honored the memory of Confucius with

THE 'CLEAR FAR-SEEING TOWER' OR LOOKOUT IN THE MIDST OF THE EXAMINATION HALLS AT NANKING.

special ceremonies. Under him, the system of education, dimly begun before Abraham left Ur of the Chaldees and continued till to-day, took on most of its modern aspects, so that 627 A. D. may be taken as the real birth time of this method of preparing statesmen by study and degrees. The colleges in Peking and all the chief cities were coordinated, and the officers of the empire recruited from the examination halls. These literary degrees in China dating from the seventh

MAIN CORRIDOR, EXAMINATION HALLS, CANTON. Long rows of stalls on either side at right angles to the walk.

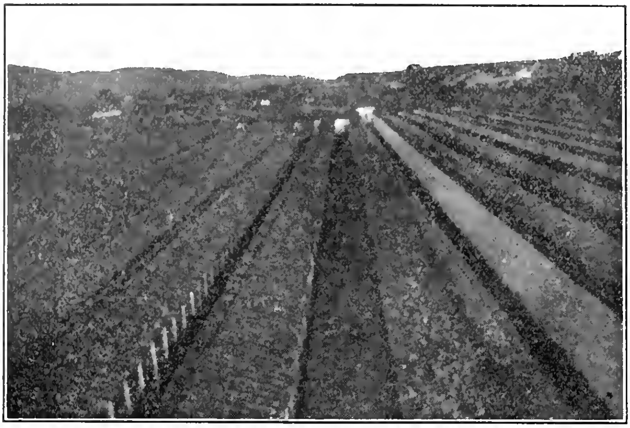
century are the most ancient literary rewards still in use in any country. In the days of the Tangs also, the examinations were placed under the Board of Rites, and military examinations and medical colleges of a very primitive character were established.

For the purposes of general government each of the nineteen provinces of the empire is divided into ten, fifteen or twenty prefectures, and, according to the system now passing away, each prefectural city, or county seat, has been a headquarters for the first degree, which is called Hsiu Ts'ai, or 'Flowering Talent.' Two resident examiners in each prefecture have kept records of competing students and exercised them from time to time. A literary chancellor in each province has held office for three years and visited each prefectural city to hold bi-annual examinations for the first degree. The halls in which these tests have been held are elaborate sets of buildings, where the students could sit in long rows and write their themes on topics taken from or dealing with the string of ideas which comprise the content of Chinese education. About two thousand were accommodated at once in an average test.

The trials for the second degree, Chü Jên or 'promoted scholar,' have been held in the provincial capitals, and the vast halls arranged for this purpose provide individual stalls sometimes, as at Nanking, for thirty thousand candidates at the same time, in which the aspiring scholars had to spend three sessions of three days each endeavoring to compose victorious essays on themes relating to Chinese history, philosophy, criticism and various branches of archeology, besides trying their skill as writers of poetry. Two special examiners for each province, generally Hanlin, were deputed from Peking to conduct these great triennial examinations which were the most elaborate and characteristic of the whole system. In them, as also in the tests for the first degree, the coveted honor was bestowed on not more than one per cent. of the candidates. The unsuccessful, however, were allowed to try again indefinitely, which some did.

The third degree, denominated Chin Shih, or 'Fit for Office,' has been awarded every three years in Peking, cabinet ministers presiding. The fourth degree has also been awarded every three years at Peking, the trial taking place in the palace and all the successful candidates becoming Hanlin, or members of the 'Forest of Pencils,' an association of imperial scribes, which constitutes one of the pivots of the empire and the very center of its literary activity. Membership in this Imperial or Hanlin Academy has then been the goal of literary attainment, for this long series of contests has culminated every three years in the appointment by the emperor of a member of the academy as the model scholar of the realm.

To any one of these examinations only those were eligible who held



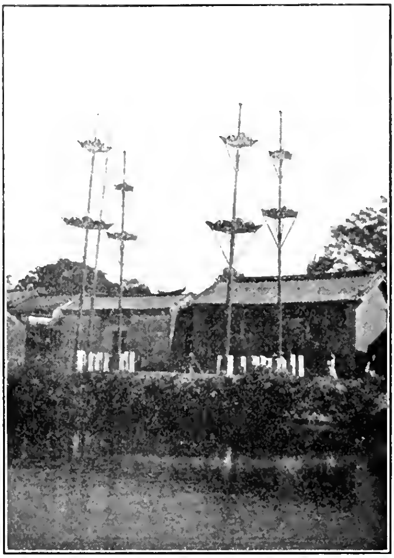
Rows of Examination Stalls at Nanking, as seen from the 'Clear Far-seeing Tower.'

in good standing the next lower degree. But there has been an imperial examination in the presence of the emperor open to all those who had at least the second degree. Those who attained the highest rank were made district magistrates. The men in the second grade were styled 'professors.'

Some idea of the tremendous importance of any change in this system may be secured from the consideration that some 760,000 candidates competed biennially for the first degree, while about 190,000 competed triennially for the second degree—a total of 950,000 for the whole empire. (In the United States the total enrolment in universities, colleges and professional and normal schools for 1902 was 246,000.) And this does not take into account another 1,000,000 students

Examination Stalls at Nanking, showing entrances to passages between long rows of stalls. The first stall in the right hand pasage is seen. Successive rows indicated by characters from the Millenary Classics.

who underwent preliminary tests at some 1,705 matriculation centers before they could enter the lists for the first degree. (In the United States the enrolment in public high schools and private academies and seminaries for 1902 was 735,000). Nor does it count the candidates for the third degree, triennially conferred at the capital. The stone lists at Peking show the award of 60,000 third degrees in the last 600 years. This system, operating at the 271 degree-giving halls throughout the empire, has produced every two years about 29,000 'bachelors,' and every three years over 1,500 'masters' and some 300 'doctors,' or a total of 123,000 successful graduates in the three grades every six years. (In all the universities of Europe the *enrolment* is less than 110,000.)



LITERARY DEGREE POLES, erected in the native village of the graduates.

With regard then to mere numbers the recent changes in the examination system affect some two million men, the flower of the nation. Of supreme significance is the part which they have played and are still playing in the national life. As Mr. R. E. Lewis has so well expressed it, the competitive civil service examinations of China have resulted in:

> *First:* A literary caste, which fills practically all the offices of the empire, and which is, therefore, the ruling force in the affairs of China, influencing the throne, and providing the administrators of the government. *Second:* The literati are the guardians of letters, and the examplars of the 'orthodox' religion. With them, letters and religion are not distinct, but the inseparable parts of a whole. *Third:* Not only are they the practical rulers of the empire, but in all matters pertaining to western civilization or progress, commercial and educational, they were up to 1898 the most absolutely conservative. *Fourth:* Not only have they been the rulers and the conservatives of China, but the student class was in the nineteenth century christianity's strongest opponent. Besides blocking the wheels of what all western nations consider progress, they, as a class, for years stood athwart the pathway of christianity with sullen defiance.

Now, by a recent imperial edict practically the whole scheme of literary civil service examinations is abolished, and no better indication of the depth to which new ideas have permeated the empire could be given than the fact that as yet, at least, scarcely a word of protest or remonstrance has been raised, even by this class of influential men whose very position is an outcome of the system they are commanded to aid in abolishing. An edict after all is only an edict, and it may be too early yet to say just how it will be received when its measures begin actually to operate. It seems scarcely credible that it will go into full effect without some opposition in some quarters. Nevertheless, it is sure that, be the opposition what it may, the new régime is bound to triumph and produce mighty results at no far distant date. 'Out of the shadows of night an empire rolls into light. It is daybreak everywhere.'

In order to understand the 'ins and outs' of educational reform, as well as of reform in general, during the last decade in China, it is necessary to review a bit of Chinese court history.

In 1875, Prince Tsai Tien, then four years old, was selected by his aunt, the empress dowager, to succeed on the dragon throne her son, the Emperor Tung Chih, who had just died at the age of eighteen. In so doing she was led by motives of policy. There were two distinctly more eligible princes whom she ignored in order to hold the reins of government more completely in her own hands, for they were young men likely to desire to have their own way. All the conspiracies to oust the empress dowager and her partisans resulting from the choice of the infant Kuang Hsü, which was the reigning title conferred on him, were promptly crushed by the late Marquis Li Hung-chang, then viceroy of Chihli, who occupied the 'Forbidden City' with his foreign-drilled troops. In 1889 his majesty was permitted by the empress dowager nominally to assume the reins of government, with herself, of course, as principal adviser and director of affairs. For nearly ten years nothing worthy of note can be recorded, except that his actions were dominated by the influence and policy of his aunt. But the psychological moment, though utterly unforeseen, was fast approaching.

Through the continued influence of the mission schools and colleges throughout the land and the increasing contact in trade and diplomacy with western nations, western learning in all its departments assumed an increasing value, and ideas of change began to ferment in the Chinese mind. Prince Kung of the imperial family addressed the throne prior to the Japanese War, declaring that the progress of the empire demanded the casting aside of their superficial learning and the acquisition of the arts and sciences which are the foundation of the prosperity of western nations. Encouraged by the governmental approval of certain modern schools established in Shanghai and Tientsin, other men having the ear of the emperor, who was profoundly moved by the result of the war with Japan and clearly saw that there must be something wrong with his country and its mode of government, advocated the new education, and their pleas, aided by the

MR. WU, FIRST HONOR MAN AT THE LAST 'TRIENNIAL' FOR THE SECOND DEGREE IN CHE-KIANG PROVINCE.

pressure of foreign governments, notably Germany and Russia, brought about the change of policy which followed Prince Kung's memorial to the throne. The crisis arrived when Kang Yu-wei and his party of earnest, progressive young men arrived from Canton in 1898, nominally for the triennial literary examinations, but really to put on foot if possible the needed educational reforms. Kang Yu-wei became the confidential adviser of his majesty, and the first imperial decree seeking to inaugurate an era of general betterment in government and education was issued January 17, 1898. This was followed on June 23, with a decree ordering the Board of Rites to remodel the examinations, saying:

> We have been compelled to issue this decree because our examinations have degenerated to the lowest point, and we see no other way to remedy matters than by changing entirely the old methods of examination for a new course of competition. Let us all try to reject empty and useless knowledge, which has no practical value in the crisis we are passing through.

The emperor further called for the establishment of a government university of foreign literature and science at Peking and of provincial schools of three grades: (1) in provincial capitals, (2) in prefectural cities, (3) in district cities, and demanded an immediate census of existing colleges and free schools providing that funds for education be derived from the earnings of the China Merchants' Steam Navigation Company, the Imperial Telegraph Administration, the Weising Lottery and the gifts of wealthy men, who were to be rewarded with rank beyond the usual scale. All memorial or other temples, except those in which sacrifices are required by edict, were to be turned into schools and colleges for the new learning, and all who studied in and graduated from these new institutions were to be accepted in the government service in the usual way. Other edicts commended copyright and patent privileges and offered rewards to authors of books and inventors of machinery and works of utility.

Considerable consternation was caused by these decrees. So long, however, as the reforms did not interfere with the dominance of the dowager, she offered no great opposition; but when the reformers aimed at her confinement at Eho Park, so as to remove her from the scene of action, she, backed by the reactionary party, which, after all, comprised the most powerful portion of both the metropolitan and the provisional mandarinate, promptly brought about the *coup d'état* of September 22, 1898, by which her majesty removed Kuang Hsü from power, became regent both in name and in fact once more, ordered the execution of Kang Yu-wei and many of his supporters of lesser rank, and cashiered those of higher station. Kang Yu-wei escaped, but six promising young men were put to death without trial within a few days. On November 13, the empress dowager issued a decree approving a memorial from the ministers of the Board of Rites, dilating on "the supreme importance of making it known throughout the whole empire that there are to be no changes from the old method of literary examinations among candidates for degrees, in order to set at rest, once for all, the present uncertainty that has been caused by the emperor's recent reform measures in the above direction."

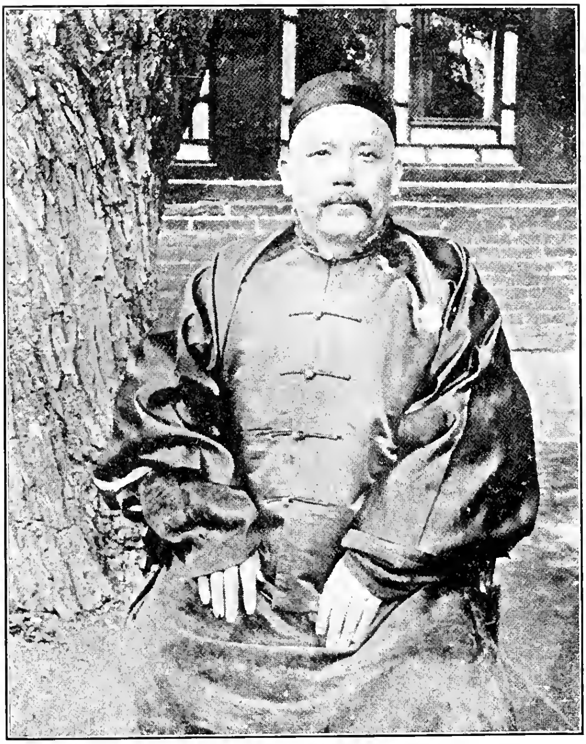
Thus an era of intensified, bigoted conservatism returned, and strange to say, the literati, who as the real leaders of the people had for so many years solidly opposed western education, were the chief mourners. According to Mr. R. E. Lewis, there is evidence that in the inland provinces of Honan, Hunan, Shansi and Szechuan, as well as in the literary centers nearer the port cities, the literati were greatly disappointed when the Manchu clan leaders crushed the plans of reform. This new attitude of the literati was a revelation to most onlookers and foreshadowed the remarkable way in which more recent changes have been received by them.

The leaven which the emperor had introduced was working in the empire, though he himself was a discredited prisoner in his own palace.

Editors of vernacular journals throughout the country, especially in Canton (the very stronghold of literary conservatism, yet the place where Kang Yu-wei had been conducting his progressive school) continued the crusade of reform, so that "one believed a cleansing storm would soon pass over the land. And the storm came drenching part of the country in blood." The era of conservatism and opposition to things western culminated in the Boxer uprising of 1900, which put Peking into the hands of the allies and drove the imperial court into exile as far as Hsian, the capital of Shensi province. Here in 1901, while still in exile, the empress dowager, into the hearts of whose advisers a desire for better things had come as a result of the lessons taught by the allies, astonished her people and the world by promulgating the very educational reforms for which the emperor had been deposed. Her decree provided that henceforth in provincial and central examinations the three groups of subjects should be as follows: (1) Five topics relating to the government and history of China; (2) Five themes upon the government, arts and sciences of all lands; (3) Exposition of two passages from the 'Four Books' and one from the 'Five Classics.' Examiners were commanded to weight the three groups equally, and in exposition of the canonical books candidates were forbidden to use the form of the eight-legged essay, hitherto required. In writing on the practical subjects in groups 1 and 2, the presentation of reality and not empty rhetoric was enjoined.

But it would be rash to declare this reform to have been complete in fact. 'Clean sweeps' are rare, perhaps rarer in China than elsewhere. How by the stroke of the imperial pen can the mind of the nation take a new course and a million of men yearly become acquainted with 'modern matters'? The vastness of the problem requires years of intelligent, patient effort for its solution. Most of the chancellors are as ignorant as the students they are set to examine as to the 'laws, constitutions and political economy of western lands.' In Shangtung at the first examination after the reform decrees of 1901, the chancellor did indeed prepare a list of books by means of which the candidates were to prepare themselves in such matters as 'political economy, commercial intercourse, military training, common law, international law, astronomy, geography, physics, mathematics, manufactures, sound, light, chemistry and electricity.' But the list, while containing one good arithmetic, consisted chiefly of out-of-date books, several lists of scientific terms, a scientific magazine defunct some ten years before, the whole being thrown together without order. Yet it is certain that a list of text-books in general use in the foreign-conducted schools of China was presented to him, though no use was made of it.

In order to get an idea of the exact nature of the change brought about in the subject-matter of the examinations by these decrees of 1901, let us compare briefly some of the questions and topics of the old régime with some of the most recent ones, *viz.*, those of 1903, which are the last to be given under the passing system. To make our survey representative, we shall in the case of the recent examinations consider those held in Chihli as the province containing the capital of the realm, in Shangtung as the province where Confucius and Mencius lived and taught, in Kiangsu as the province of greatest literary



YUAN SHIH-KAI, VICEROY OF CHIHLI, CHIEF MEMORIALIST IN BEHALF OF EDUCATIONAL REFORM. The most powerful subject in China.

fame, and in Canton as the province deemed most conservative in literary affairs.

SAMPLE THEMES OF THE OLD SYSTEM.

1828. From the 'Four Books.' To serve as topics of essays.

To possess ability, and yet ask of those who do not; to know much, and yet inquire of those who know less; to possess, and yet to appear not to possess; to be full, and yet appear empty.

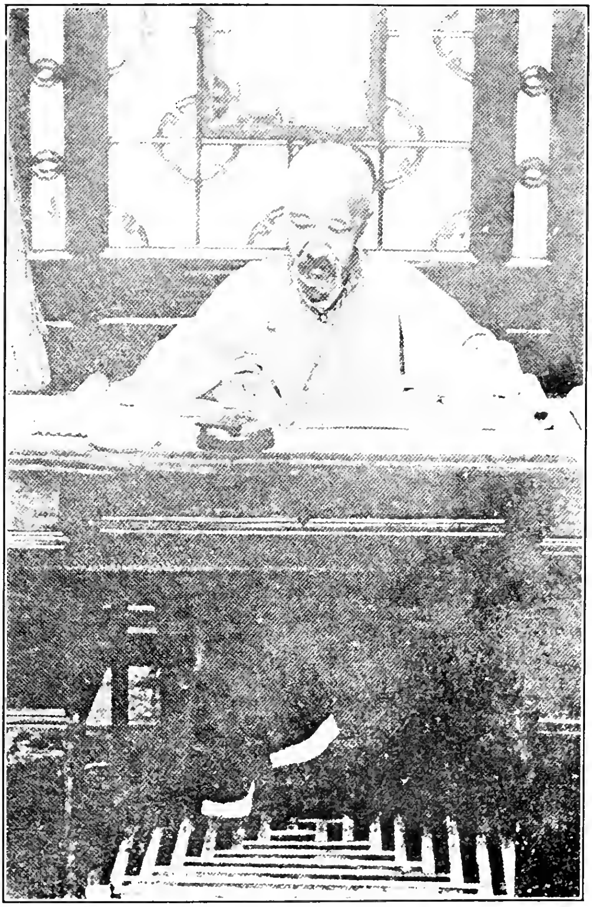
He took hold of things by the two extremes, and in his treatment of the people maintained the golden mean.

A man from his youth studies right principles, and when he arrives at manhood, he wishes to reduce them to practise.

In pentameters write on The sound of the oar, and the green of the hills and water.

1835. He acts as he ought, both to the common people and official men, receives his revenue from Heaven, and by it is protected and highly esteemed.

(More practical.) Fire arms began with the use of rockets in the Chau dynasty; in what book do we first meet with the word for cannon? Is the defence of Kaigungfu its first recorded use? Kublai Khan, it is said, obtained cannon of a new kind; from whom did he obtain them? When the Ming emperors, in the region of Yunglok, invaded Cochinchina, they obtained a



CHANG CHIH-TUNG, VICEROY OF THE HU KUANG PROVINCES, who aided Viceroy Yuan Shih-Kai in preparing the memorial advising the abolition of the examination system.

kind of cannon called the weapons of the gods; can you give an account of their origin?

1853. In the Han Dynasty, there were three commentators on the Yih King, whose explanations, and divisions into chapters and sentences were all different: can you give an account of them?

Sz'ma Tsien took the classics and ancient records in arranging his history according to their facts; some have accused him of unduly exalting the Taoists and thinking too highly of wealth and power. Pan Ku is clear and comprehensive, but on astronomy and the Five Elements, he has written more than enough. Give examples and proof of these two statements.

Chin Shao had admirable abilities for historical writings. In his San Kwoh Chí he has depreciated Chu-koh Liang, and made very light of I′ and I′, two other celebrated characters. What does he say of them?

From the 'Five Classics.' Treatment to be more recondite and in a higher style.

When persons in high stations are sincere in the performance of relative and domestic duties, the people generally will be stimulated to the practise of virtue.

Essays in this section were characterized by a jejune style and reasoning in a circle. Such topics as were given throughout the whole

Entrance to the Headquarters of the Bureau of Education for the two Kwong Provinces, Canton. Commodious buildings erected in 1889 by Chang Chih-tung as editorial rooms in connection with a large old-style school started by him when Viceroy in Canton. Occupied by the New Bureau of Education in 1903.

system involved a wide range of reading in the native literature, but narrowed the vision to regard this literature as containing all that is worth anything in the world. Yet the discipline of mind and memory incident to preparing for these tests, supplemented by the friction and experience of public life, made statesmen out of scholars and did much to give China her influence in Asia. Contrast these topics, however, with more recent ones.

SAMPLE THEMES FROM THE LAST TRIENNIAL EXAMINATION (1903). ON SYSTEM AS MODIFIED BY EDICT OF 1901.

Group II. Modern Matters.

Five questions or topics in such examination for the second degree are proposed for discussion in this group. We present selected ones from those assigned at four chief literary centers in North, Central and South China. Where we present less than five questions for one center, it is because those omitted are practically duplicated by those presented for other centers.

Peking, Chihli.—2. Western commerce depends essentially upon knowledge of animals and plants. Cattle and sheep are raised by regulated methods, climates fit for separate kinds of cattle are distinguished, soils and their specific adaptations are studied. China should find out the best way to promote industry and commerce in like fashion. Discuss this.

3. Metternich and Bismarck greatly aided in the advance of their countries. Tell briefly what they did.

4. We should study Chinese literature as a subject in itself. Discuss whether Chinese literature should be a subject in a scheme of modern education.

Tsi Nan, Shangtung.—1. Western economists always say that the production of wealth depends entirely on the three elements: Land, labor and capital. But the capital of China is getting less and less, when we Chinese want to do business we have to invite foreign merchants as partners, and the poor people who are out of work have to go to foreign countries to labor in order to earn their living. What must we do on the whole to strengthen our country and get back all the lost profits from foreigners?

2. No people can live without society. But where there is society there is struggle. The English scholar, Herbert Spencer, says: It is good for people to form societies, and that through wars a people are compacted. When the people are more of a unit, progress is easier and a higher civilization will be attained. And again, he says that among those people who like to fight wars, civilization will decline or be retarded. What does he really mean by these seemingly opposite expressions?

3. Penal codes of the east and west are different. One is severe and the other lenient. Since Japan has changed her penal code, she has gained power to punish even foreign offenders residing in Japan and to deal with other nations. China has changed a little in dealing with foreigners in the treaty-ports. But this rule differs from the method of internal or interior rule. If we want to change the penal code entirely, do you think there would be opposition from the people? If there is no opposition, can it be made universal throughout China?

4. Since the government has allowed the presence and work of foreign missionaries many foolish people have sought refuge from the law of the land under the protection of the missionary by becoming converts and some anti-christians make a great deal of trouble throughout the empire. Because of this foreigners look down on China and declare that she is a country without education and without religion. But foreign scholars who are familiar with the literature of China say that five hundred years hence, Confucianism will be spread over the whole world. The trouble at present is that we do not know how properly to propagate Confucianism, and not that the foolish people who are false christians can injure our religion. If we want our religion to grow and the people to progress, what shall we do, what is the best plan to follow?

5. All the nations of the world have now come into relation with each other by interchange of intelligence and commodities. Before this they had to

protect their coasts and borders, but now they must maintain navies. But in the present condition of China, the navy is not well organized, the forts and fortifications have been destroyed and abandoned. The ports have been leased to foreigners. All the doors have been opened. Certain foreign railroads can go straight into Chinese territory. The condition of Manchuria and Tibet is critical. Neighboring nations are seeking an entrance. We can not rely on our dependencies for support. If we want to develop a strong army and navy, what is the best way to do so? Suggest the best plan to follow.

Nanking Kiangsu.—1. Western countries have established commercial centers and subsidized and protected great enterprises, railroad and steamship lines for transportation, banks and newspapers as a key to unlock the country's resources, postal routes and telegraph lines to spread news very quickly, and schools for education. In what order as to importance should we establish these things in China, according to the western principle?

2. Post offices are now gradually being established all over China. Tell by what postal routes and over what distances letters can be sent and how many offices there are. Should we establish any more? How improve the postal service?

3. At what place to the south of Europe are the Caucus. Has it any other name? Russia took it and established many new laws—what are these laws and when established?

4. Opium and salt taxes. In the last few years many provinces have paid different amounts toward the war indemnity to foreign countries, because the taxes in these provinces are different. There is much squeezing and the people suffer. Now we ought to get a good way to conduct this business. Suggest a plan.

Canton, Kwangtung.—1. Western countries all use gold coinage. They have the cent and shilling for local exchange and these have a fixed value. The government of China is planning to change its currency to a gold basis. The dollar and the cent of China ought to have a fixed value so as to expedite the payment of taxes and benefit the country. Discuss this proposition.

3. Industrial schools are good for the poor people. If China has this kind of schools the necessity of importing foreign goods will be done away with. Philanthropic societies in all the districts of China have done good work in aiding the poorer classes of the community. If we want to use a part of the funds of such societies to build industrial schools, so that the poor may have an education—to earn a living, besides being fed—in addition to these funds, what other way could be employed to secure money for this purpose?

4. Foreign countries have power to manage their own affairs in the treaty ports of China. When the Chinese have trouble with a foreigner, they do not have the same or equal standing in the court or in the community at large. We want to alter the law and adopt some of the laws of foreign countries and to establish a code for international relations so that if we have affairs with foreigners, we can have the right to administer justice so that foreigners can not be unjustly shielded.

The introduction of even such meager questions in western sciences was an entering wedge which, aside from the more recent decision to eliminate the classical requirements entirely, was destined to lift the Chinese out of their medieval scholasticism into the full light of modern knowledge. The reform edict of the dowager was accompanied by other edicts providing for sending young men abroad to study, for the establishment of provincial colleges and the organization of a common-school system. Already these young men are returning, some of them with honors from the best schools of the west; and one of them, who also holds his Chinese second degree, wrote two years ago:

Every Chinese man knows that the examination system is not good, and so the government has resolved to establish schools, colleges and universities, instead of all the kinds of examinations. For the examinations of the next term, the number of Hsiu Ts'ai, Chü Jên and Chin Shih will be diminished and, several years after, all the examinations will be dismissed.

Thus the recent decree giving the last blow to the old system was not entirely unforeseen, though it was scarcely expected so soon.

H. E. Yuan Shih-kai, holder of the senior viceroyalty of the empire, that of Chihli, the most powerful subject in China, and the very man whose devotion to the empress dowager when the emperor called for his assistance in 1898 made her *coup d'état* possible, sent in a memorial which was approved and made operative in an imperial decree dated September 2, 1905, advocating the summary abolition of the old style literary examinations, in order to allow the expansion of modern modes of education throughout the empire. Associated with him as memorialists were H. E. Chao Erh-sên, the Tartar general of Mukden and viceroy of Fêngtien province (Lower Manchuria), H. E. Chang Shih-tung, viceroy of the Hukuang provinces, H. E. Chou Fu, acting viceroy of the Liangkiang provinces, H. E. Tsên Ch'un-hsuen, acting viceroy of the two Kuang provinces, and H. E. Tuan Fang, governor of Hunan province. This is the strongest list available throughout the whole empire, and it was but natural that the empress dowager should have been so impressed that even if she were at heart opposed to the epoch-making step, she could but tell the emperor to sanction it, in spite of the opposition which Wang Wên-shao, Lu Ch'uan-lin and others are reported to have made against the 'revolutionary' memorial. Though signed by this group of influential viceroys, the plea was really the work of H. E. Yuan Shih-kai, assisted by H. E. Chang Chih-tung. With their unfailing astuteness, they point out that what they propose is not after all a new scheme, but a return to a former usage. The literary examinations may seem to us of venerable antiquity, but these viceroys point out that they are really modern innovations on an older and much better system which they desire to recall. Theirs is not the destructive hand of the reformer, but the conservative hand of the restorer. The decree says:

Before the era of the 'Three Dynasties,' men for office were selected from the schools, and it must be confessed that the plan produced many talented men. It was indeed a most successful plan for creating a nursery for the disciplining of talents and the molding of character for our Empire of China. Indeed the examples before us of the wealth and power of Japan and the countries of the west have their foundation in no other than their own schools.

Just now we are passing through a crisis fraught with difficulties, and the country is most urgently in need of men of talents and abilities (of the modern sort). Owing to the fact that of late modern methods of education have been daily on the increase among us, we issued repeated commands to all our viceroys and governors of provinces to lose no time in establishing modern schools of learning in such number that every member of this empire may have the means of going there to study and learn something substantial in order to prepare himself to be of use to his country. We have indeed thought deeply on this subject.

The decree then states that the ministers of education have suggested the gradual abolition of the examinations, but Yuan Shih-kai, whose experience and knowledge are admitted, 'asserts that unless these old-style examinations are abolished once for all, the people of this empire will continue to show apathy and hesitate to join the modern schools of learning.' Yet it would seem that the demand for the change had really come from the people.

Hence if we desire to see the spread of modern education by the establishment of a number of schools, we must first abolish the old style of studying for the examinations. . . . We therefore hereby command that, beginning from the Ping-wu Cycle (1906), all competitive examinations for the literary degrees of Chü Jên and Chin Shih (Master of Arts and Doctor) after the old style shall be henceforth abolished, while the annual competitions in the cities of the various provinces for the Hsiu Ts'ai (Bachelor of Arts) or licentiate degree are also to be abolished at once. Those possessors of literary grades of the old-style Chü Jên and Hsiu Ts'ai who obtained their degrees prior to the issuance of this decree shall be given opportunities to take up official rank according to their respective grades and abilities.

So that literati who already hold Chinese degrees are not entirely neglected, but will have to buy text-books and attain a smattering at least of western knowledge if they wish to keep up. The rest of the decree urges all officials from viceroys to district magistrates to see that schools of all the necessary grades are established, and the ministers of education to distribute text-books at once to all the provinces, 'so that we may have a uniform system of teaching in all our schools.' A word of encouragement is added to soothe the country and induce it to meet freely the expense of these radical changes: 'The government being thus enabled to obtain men of talents and abilities, it follows that the cities and towns producing such bright lights of learning will also enjoy a reflected honor therefrom.'

Subsequent decrees (September 4 and 7) give the literary chancellors of the various provinces the duty of holding examinations and inspecting the schools of modern learning in the province to which each had been appointed in the old régime, and command each to act in conjunction with the viceroy or governor of his province, the control of the whole being removed from the Board of Rites into the hands of the ministers of education. The establishment of a special board for educational affairs will soon be confirmed under the title Wen Pu or Board of Literature.

It was rather the abuse and not the fault of this literary civil service system that it compelled the mind of China to grind for ages in the mill of blind imitation. A competition which excited the deep interest of a whole nation must have exercised a correspondingly profound influence upon the education of the people and the stability of the government. The old system has cherished whatever national education there has been, and when the influence of western science predominates, as it is beginning to do, we shall see thousands, yea hundreds of thousands, of patient students pursuing scientific studies with an ardor equal to that formerly bestowed on literary competition. The problem of transition is a vast one, and not till men of modern training, necessarily young men, are appointed to the literary chancellorships of the empire, can this new and practical system be adequately established. But the struggle against custom and conservatism is on —probably an intense and prolonged effort, for these do not vanish in a day even in the presence of a goodly band of reformers—and from the struggle the rising race of modern students will come forth victorious to lead their country into the splendid destiny that awaits her.

It remains to be seen just what measures will be taken to establish adequate and efficient modern schools throughout the empire, but already the prime movers in the recent memorial have announced some very ambitious schemes. The viceroy of Chihli has decided to establish a monster normal school at Tientsin in order to prepare men to teach according to modern methods. It will be modeled after the one at Nanking, and will matriculate from Fêngtien, Shangtung, Honan and other provinces, as well as from Chihli. The president will be a returned student from Japan, Chin Pang-ping, who was recently awarded the Hanlin degree after passing a special examination. At Peking it is planned to erect new buildings on a site of more than 2,800 English acres, and to supersede the present Peking University with this new Imperial Chinese University. Dormitory accommodations for some 20,000 students are to be provided, while a portion of the grounds will be set apart for agricultural experiments. The site of the present university is to be utilized for the erection of a school for the daughters of princes, nobles and high ministers of state, which has been sanctioned by the empress dowager in response to the recommendations of H. E. Chang Pei-hsi, minister of education and president of the Board of Revenue, and H. E. Tuan Fang, substantive governor of Hunan province and one of the five imperial commissioners appointed to visit abroad.

At Canton the abolition of the biennial and triennial examinations causes a loss to the provincial treasury of nearly $350,000 silver annually, as this sum was paid by a clique of wealthy gentry for the monopoly of conducting the Weising Lottery in connection with the examinations. It is reported that this serious deficit is to be met by arranging a domestic loan of three million taels at seven per cent. repayable in instalments within ten years, and that Viceroy Tsên has already received the imperial sanction to float this loan, which will be secured by other gambling monopolies, and has promised that the money thus obtained will be used only for local public works and for schools. The provincial government over a year ago opened a modern normal school in the ancient Examination Halls of Canton, under Japanese direction, and there are some 120 men over twenty years of age studying there, and also some 60 boys enrolled in a practise school.

To what extent existing government, privately endowed, and christian mission schools are prepared to meet the increased demand for modern education which these recent decrees will undoubtedly create might well form the subject of another paper. Suffice it here to point out the tremendous opportunity and responsibility thus presented to christian educational missions. The extent and geographical character of China and its division into provinces under viceroys makes China resemble America more closely than any other country, and we believe that the kind of informal, yet none the less real, national system of educational work in the United States is what China needs. America's merchants are invading the east with marked success, and her diplomacy is affecting the right course of political events. American educators should aid in the educational conquest just as fully. There could be no better way of showing our true friendship, in spite of recent events in connection with our enforcement of the Exclusion Treaty and China's boycott of American products, than thus to aid in the true enlightenment of China's millions. Aside from the motive of christian missions, our prestige in the east demands such altruistic effort.

THE LAPSES OF SPEECH[1]

By Professor JOSEPH JASTROW
UNIVERSITY OF WISCONSIN

A SPECIAL interest attaches to the psychological relations of speech—an interest shared by the philologist, by reason of his recognition that the mode of use and growth of language, in spite of its arbitrary accretions, reflects the native traits of the impulses that gave it being; by the psychiatrist, for whom the observable disturbances of speech offer the most delicate and distinctive criteria of the nature and extent of inner defect; and by the psychologist, for its unique status as the embodiment and recapitulation, racial and individual, the record as well as the means of advance of the psychic endowment in efficiency, in scope and, above all, in analytic insight. Indeed there is hardly an aspect of the psychologist's pursuit that does not find pointed illustration among the extensively variable phenomena of language. I propose to indicate such of the habits, and particularly of the lapses of speech, as reflect the subconscious processes that participate in its normal functioning.

Psychologically, speech is but one of several modes of indicating that we appreciate the situations that confront us, that we judge and assimilate and combine these in rational fashion, and that we shape our conduct accordingly. A chess-player exhibits all this as distinctively as a debater; and the moves of the one, though quite remote from any verbal expression, are closely parallel to the arguments of the other. The analogies of speech with other forms of intelligent expression favor the expectation that the lapses of the two will exhibit a considerable range of resemblance; for both will be expressive of the common habit of the mind to step and trip in set measure. The reduction of ideas to words and the marshaling of words in expressive and conventionally regulated sentences is an intricate accomplishment, even to the expert; like all such, it requires that the technique thereof, the ability to register and manipulate the common factors that enter in kaleidoscopic shifting of position into the pattern of the fashioned product, shall have become a well-drilled habit. If we could look upon an exhibition of the art of constructing sentences with something of the objective, uninitiated attitude with which we observe the bewildering flight of the scores of bobbins and the shifting of the pins of the lace-maker, we should marvel

[1] This article will form an appendix in the volume, 'The Subconscious,' shortly to appear from the press of Houghton, Mifflin and Co., Boston.

equally at the skill of the verbal craftsman, who, like the other, must take up each thread in just the right order, give it just the right twist, and make of the whole amazingly intricate business not the seemingly inevitable tangle, but a beautiful, orderly design. It is, indeed, easily intelligible that, in moments of wavering oversight, slight snarls and slips should occur. An intimate analysis of these lapses of speech may reveal details, by no other evidence so clearly exhibited, in regard to the subconscious operations that are normally required to shape sense and utterance to a successful issue.

The central relation seems to be this: the complexity of speech requires the occupation with many processes at once, and some of these—the nicer, more delicate, less familiar ones—will receive the major attention, while the routine factors engage but a minor degree of concern. Slight fluctuations in the condition of the speaker—physiological ones, such as fatigue, and, for the most part, psychological ones, such as excitement, apprehension, embarrassment—will induce variations in the nicety of adjustment that are recognizable as typical slips of tongue or pen, and, still more significantly, of the tongue-and-pen-guiding mechanism. Conformably to what is true of lapses of behavior in general, such slips will be predominantly expressive in type. We know what we wish to say; we give over the saying of it to the usual faithful mechanism, which on this occasion drops a stitch, or takes up the bobbins in wrong order, or plainly tangles the threads. With but one right way and so many wrong ones, it is significant that our departures from the intended design are so predominantly of a few types. There are the anticipations, the persistences, the interchanges, the substitutions[2] and the entanglements of letters, and of words and parts of words, and of phrases—all of them indicative of shortcomings in the minute distribution of attention and coordination. That which is now subconsciously in the margin and is being prepared for utterance, emerges ahead of its time; that which is waning after utterance persists too long and reenters the articulatory field; or both processes occur, the second, having usurped the place of the first, tumbles the legitimate predecessor into its own vacancy, while the more variable

[2] I shall not consider the difficulties of speech-coordination, such as speaking, *She sells sea shells*, or, *Peter Piper picked a peck of pickled peppers*, or in German, *Die Katze tritt die Treppe krumm*, or individually tripping words such as *Detektivtaktik*, though these are nothing more than pronounced cases of certain of the lapses considered. The one offers intrinsically difficult coordinations, upon which even deliberate effort may trip; while the other is usually accomplished with ease, but under released tension of guidance invites failure. Likewise have I, in citing instances, passed at once to the more complex and more natural ones, omitting those of formally simpler type. I must acknowledge my indebtedness for most of the illustrations to H. Heath Bawden: *A Study of Lapses*, 1900; and to Meringer and Meyer: *Versprechen und Verlesen*, 1895.

slips require, as do the more pronounced lapses of conduct, some illumination from the introspective side.

Whether we are speaking, or are reading aloud from the printed page, or are copying, or are engaged in original writing, we are likely to find that which is about to enter the motor field anticipating its utterance: for *between feeling and willing*, there emerges *between filling; expert persons* becomes *expersons;* a lecturer alludes to *the tropic of Cancercorn;* in public reading, *the beautiful is as useful* is rendered *the buseful;* in writing *pieces of machinery,* the pen writes *pieches.* So also in German: *Sturm und Drang* becomes *Strang;* one intending to say *Nach Innsbruck aus München* says *Nach Minnsbruck;* so also *Minuster für Kultur und Unterricht; Es war mir auf der Brust so schwer* emerges as *Es war mir auf der Schwert;* and (with the slip immediately noticed and corrected), *Die Sympather . . . die Japaner sind mir viel sympathischer.* So with persistence of words or fragments thereof: With *revelation* in mind, the speaker actually said, *Those who believe in evolution think that revolution;* and we meet with *refinement and gentlement* (*gentleness*)*; secluded retruts* (*retreats*)*; Die Psalmen sind Producte der jüdischen Müse* (*Muse*). Slips of anticipation are naturally more frequent than those of persistence, for the reason that the margin that is qualifying for consciousness is naturally closer to our concern than that which is dismissed or dismissible; and, perhaps still more naturally do both appear at once, thus producing interchanges of the threads of utterance. *Portar and mestle; in one swell foop; dame, leaf and blind; sody and boul; Phosford's acid Horsephate; go out on the corch to pool; make a noyful joise*—these hardly need interpretation, as execution reveals intent. Somewhat more divorced from meaning, yet intelligible, are, *Are you strailing out for your mole?* (*strolling out for your mail*)*; which he whiches* (*wishes*)*; the water the wetter* (*the wetter the water*)*; flutter by* (*butterfly*). *Put the tray on the weights; going to the coal to buy the wharf; set your leg on four chairs,* are simple in formula; but *I bought three dollars* for *I bought my dress for three dollars; collooding* for *colliding in the loop; put plustard* for *put mustard and flour in the plaster*, are clear only after the intention is revealed. The German offers parallel models: *Die Milo von Venus; Wertlaut* (*Lautwert*)*; Einen Zuck Huter* (*Einen Hut Zucker*)*; Ich verganz gass* (*Ich vergass ganz*)*; Zwecktischer Prak* (*praktischer Zweck*)*; Tapps und Schnabak* (*Schnapps und Tabak*).

There are still more complex cases in which various of these factors and others combine to give the substituted expression more misleading similarity to the proper one. When the perverted phrase is meaningless and sounds strange to the ear, we are quite likely, though by no means certain, to become aware of the lapse;[3] but when it has the glib sound or semblance of sense, it passes unnoticed before the sensory sentinel. The much-cited scholar who spoke of the *half-warmed fish* that one feels in one's breast (*half-formed wish*) perhaps reached the acme of sensible sounding absurdity. On the same plane is the statement that *We have a very queer dean* (*a very dear Queen*)*;* while the speaker who converted *little ditches branching off* into *little britches dancing off,* departed from strict linguistic interchange by the logical attractions of *dancing* (it should have been *danching*).

It is to be noted that most of these lapses are peculiar to speech (vocal utterance), because this is the more fluent, more automatic expression; and further that these speech-lapses are apt to be favored by any slight indisposition or fatigue or excitement. One collector of such linguistic frailties notes that they occur more frequently at the end of an evening's conversation than at the beginning. Certain of the lapses are characteristically oral; a smaller class graphic; still others common to both forms of expression; while even in that half-innervated process of reading to one's self, or formulating one's thought in words (as in preparing for an address) do these lapses become cognizable to the semi-articulate consciousness. The lapses of writing are both less frequent and simpler than those of speech, because in writing we proceed by smaller units, and write as a rule with more alert attention than we give to casual talk or even to careful utterance. Graphic lapses will accordingly be apt to occur in rapid and absorbed composition in which thought runs well ahead of execution, or will occur in ordinary writing and be slight in character.[4] By virtue of the same relations, the more poised temperaments and deliberate speakers on the one hand, and those whose expertness in speech does not permit them so readily to commit execution to subconscious guidance (children and the uncultivated) on the other, will not be as subject to speech-lapses as the more fluent and venturesome speakers. Lapses of speech, like lapses of conduct, are favored by that inattention which we are disposed to give to ingrained and well-habituated activities.

Interrupting the taking of testimony at this point to interpret the evidence, it is obvious that these lapses follow definite trends, illustrative of our psycho-linguistic mechanism. Both anticipated and per-

[3] This suggests the placing of the wrong arm first into the sleeve, with a consequent awkward feeling; or the exchange of hats without observing the absence of the familiar recognition-marks.

[4] The typewriting manipulations have an appreciably different status from those of writing, notably in the number of separate mechanisms (fingers) that each may participate in the reaction; yet typewriter lapses are common, and in part conform to the linguistic types. Letter interchange is decidedly the most frequent slip (*rt* for *tr*, *oi* for *io*, etc.), though the other formulæ also apply.

sistent and interchanging parts of words, and parts of phrases, yield to confusion because of the psychological equivalence of the confused portions. Such equivalence of value or function in the attentive consciousness of the sentence-builder is determined by many considerations. Similarity of sound; similarity of stress; similarity in the syntax of phrases; similarity of position; similarities due to subjective attitudes—all enter in separate or combined form. Most conspicuous are confusions of the initial sounds of words; those for the leading words in the sentence receive about the same prominence of emphasis; thus *corch* and *pool, noyful* and *joise, watter* and *wetter.* The reader need only reread the series of lapses just recorded, with his attention directed to the relative balance or equivalence of the confused sounds and words, to find convincing proof of the parallelism that determines such confusion. There is even a slight advantage in taking foreign sounds in which, with the meaning less prominent, the sound-values to our apperception stand out more conspicuously. We can appreciate how readily *Alabasterbüchse* becomes *Alabüchsebaster* (interchange), or *Alabasterbachse* (persistence), or *Alabüsterbüchse* (anticipation); while *Paprikaschnitzel* not only emerges as *Piprikaschnatzel* and the other variants, but is even recorded as being contorted into *Schniprikapatzl.* When, however, *fröhliche Festfeier* emerges before the astonished hearers as *Festliche Fressfeier,* one appreciates that the accidental pertinence of the result may have been a still deeper subconscious inducement to attract the utterance into the form that likewise meets the linguistic expectations.

What all this means in terms of psychological processes is that the constructive consciousness requires and utilizes the marginal areas that spread to either side of the progressive focus of utterance. The wider this span, the greater the area within which confusion is possible. Ordinarily lapses are confined to elements close to the central moment; occasionally they extend to the next line or the next measure of thought, while in leading up to a climax, the speaker maintains a distant subconsciousness thereof and occasionally betrays the fact by an inadvertent precipitation of what was to have been the final triumphant flourish. Quite the same relation holds within the sentence when it is a long and complex one. The German construction has an unenviable reputation in this respect, and certainly makes strenuous demands upon the architectural skill of the sentence-builder; the inclusion and sub-inclusion of phrase within phrase, each with rigidly regulated gender and case and mood and tense forms, the distant relations of the parts of the separable verbs, and the final mood and tense auxiliaries that must ever be held in mind to round up the series of grammatical obligations incurred *en route,*—these demand a wide and alert spread of consciousness and permit of little loitering by the wayside.

A proficiency in subconsciously finding words for a thought already formulated, while at the same time shaping the next thought-period in conscious preparation, is a gift of prime importance to writer and speaker alike. It reaches a most developed application in dictating for publication. A remarkable talent of this type is ascribed by his amanuensis to Sir Walter Scott. He records that Sir Walter would continue to dictate while he searched for a book, found the desired passage, and absorbed its meaning. He thus kept going two trains of thought, the one arranged and ready to be spoken, and the other in logical preparation. "This I discovered by his sometimes introducing a word which was wholly out of place—*entertained* instead of *denied,* for example;—but which I presently found to belong to the next sentence, perhaps, four or five lines further on, which he had been preparing at the very moment he gave me the one that preceded it."

The intricate art of speech thus proceeds—though naturally with the subconsciousness begot of familiarity—by a preliminary projection, an outline staking of the sentence, not yet setting words in place, but mentally mapping their positions; then by the actual setting of the corner-posts and the raising of the framework upon these supports, the two proceeding together with an accompanying preparation for the details, that in due sequence enter into and embellish the complex structure. Yet the architectural, designing or constructive simile is inadequate, because the two procedures are so inextricably dovetailed, because each section receives its plan, foundation, details and finish in one. For the weaver of words does not, like the spider, send out—except in this provisional mental planning—the main radial lines of his web, and then take up in order the cross-threads from segment to segment; rather does the whole, mainrib and cross-lines, develop progressively as the thought finds expression in orderly sentences. He accomplishes this feat by the support of subconsciously delegated functions, that reflect years of trained experience, and cooperate with consummate skill, and ordinarily with no subordinate intrusions, in the centrally directed purpose.

We resume the survey of speech-lapses by observing another group, that suggests the confusions of conduct that occur in the abstracted handling of material situations. They have been called contaminations, coalescences, fusions and the like. They lay bare the subconscious alternatives from among which consciousness ordinarily selects properly the one chosen from the several called, but in this exceptional instance allows the submerged factor to project above the surface. Upon being asked whether she had heard a certain musical composition, a young lady had in mind to answer that she had heard *scraps* of it, or again that she had heard *snatches* of it, but actually said that she had heard *scratches* of it; with *rubbers* in the background of the mind, *overshoes* became *ruvvershoes.* With *spank* in mind, the threat to paddle the refractory youngster became, *Well, I'll spaddle you;*[5] and a too hesitant wavering between *it mists* and *it drizzles* resulted in *it mizzles.* Unexpectedly lucid is the betrayal of an after-dinner speaker who planned to begin, *unprepared as I am* (*Unvorbereitet wie ich bin*), but had as a fact carefully rehearsed his part, and who actually said, *unprepared as I have myself* (*Unvorbereitet wie ich mich habe*).[6] Choosing between *Scherz* and *Spass,* the speaker said *Das ist kein Sperz,* just as we might say, That is no *jost* (*jest* and *joke*). Wishing to impart the information that he was at home until seven o'clock, and that indeed he was writing until that hour, the speaker said (and might just as well have written), *I was at home until seven o'clock was I writing.* The process has been graphically presented by indicating by the heavy line the above-the-threshold processes, and by the dotted line the sub-threshold impulses, the crossing point being the point of intrusion of the one into the field of the other.

Or thus:

The fact that we carry on a manifold activity in the expression of thought is thus sufficiently indicated, and finds marked parallelism, so far as the lapses are concerned, in the interchange of activities (the

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[5] Nonsense word makers (Lewis Carroll, Edwin Lear, *et alii*) seem to be guided by a feeling for this process, along with many other more fanciful and onomatopoetic attractions. *The Hunting of the Snark* may have a suggestion of a *snake* and a *shark; Torrible Zone* suggests *torrid* and *horrible; slithy* may be *slimy* and *writhy.* Yet these verbal aerobatics naturally involve, as well, any forms of contortion that give amusement and the sound-semblance of sense. Lewis Carroll's own characteristic elucidation is as follows: "For instance, take the two words *fuming* and *furious.* Make up your mind that you will say both words, but have it unsettled which you will say first. Now open your mouth and speak. If your thoughts incline ever so little towards *fuming,* you will say *fuming-furious;* if they turn, even by a hair's breadth, towards *furious,* you will say *furious-fuming;* but if you have that rarest of gifts, a perfectly balanced mind, you will say *frumious.*"

[6] I am assured that there is a tendency among the philologists to account for the paradoxical use of the negative and the intrusion of the negative in constructions in which it seems logically out of place, by this process of heading for the gateway of utterance with a double team, only one member of which can and should get through; it is as though the one that succeeds takes with it the harness of the other. The Frenchman seemingly has in mind to say both *I fear my father will see me,* and simultaneously *I hope my father will not see me;* and actually allows himself to say *I fear my father will not see me.* Similarly, with *John is taller than James* in mind, but also thinking the same thought as *James is not as tall as John,* the spirit of the Romance language constructions tolerates *John is taller than James is not.* Independently of the proof that may be brought to bear upon the correctness of this suggestion, it is interesting to consider whether the mental tendency, that gives rise to lapses of speech, may not also have been influential in shaping linguistic construction and usage.

dipping of the brush into the ink, the handling of a key taken from the supposed stamp-box as though it were a postage stamp, the attempt to thread a thimble) induced by moments of abstraction; while the parallelism is completed when one or other of the commissions charged upon the mind emerges into utterance at the wrong occasion, and the preoccupied shopper asks the post-office clerk for *individual salt-cellars* instead of *stamps,* because that item is next on her list of commissions. A similar verbal interchange occurs when the absent-minded professor, in writing a testimonial, records that "Mr. A. has attended my *remarkable* lectures in chemistry with *inorganic* assiduity"; or asks at the toy-shop "for a *two-year-old* book for an *indestructible* child."[7] One may experimentally induce these intrusions by giving the mind two occupations, or exposing it to two sets of influences at the same time. In writing on one topic while thinking of another, or while listening to conversation, one may find in his written words some that found origin in, or were altered by what he heard, or by what became intruded into his writing from his extraneous meditations. A single instance: a clerk writing a pass for an employee while engrossed in the shipping of cylinders, writes *From Lima to Cylinder* instead of *From Lima to Dayton.* It is a familiar experience for teachers, in asking a question, with the answer prominent in consciousness, inadvertently to use the answer in framing the question.

The intrusion of the subconscious thus becomes a widely available formula to account for verbal as well as material slips of pen and tongue and hand; and the tendency to such lapses takes one of several distinctive forms, increasing with the similarity or suggestiveness of the confused situations, and most of all dependent upon the way in which the parts of the complex occupation lie in the mind, upon the momentary diversion of the attention from the central occupation, and everywhere upon the temperament and attentive habit of the subject. In these aspects, both in their larger features and with unexpected parallelism in detail, do the lapses of speech exhibit close analogies to the more general failures of adjustment in conduct of various types, that have in common with speech lapses the combined conscious and subconscious expression of reflection and intent.[8]

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[7] I can not extend the survey to take account of the distinctive lapses of thought, which, in common with the lapses considered, involve the formulation of a fairly definite thought that uncritically reaches expression in words, which amusingly or significantly miss or distort the intention. Such is the reply of the excited old soldier to the presentation of a sword upon an anniversary occasion: 'This sword, gentlemen, is the proudest moment of my life.' A survey of such lapses of thought, for which (though not for these exclusively) we have the special term 'bull,' would introduce more intricate yet related considerations.

[8] See 'The Lapses of Consciousness' in the POPULAR SCIENCE MONTHLY for October, 1905.

WHAT IS SLANG?

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TO the purist slang is an unmitigated evil which makes for the gradual corruption and decadence of our vernacular. The pedant who is a martinet regards all slang with absolute contempt and abhors its use, because he believes slang spells deterioration for our noble tongue. Such an one takes his self-appointed guardianship of the language very seriously and deems it his bounden duty as a curator of our English speech, not only himself to spurn the use of slang, but also to inveigh against all those who employ it habitually or occasionally. The baneful influence of slang, he tells us, is sweeping like a mighty tidal wave over the English language, debasing it and corrupting its very sources.

Nor is the precisionist alone in entertaining this alarming view. For many others who are not sticklers for strict propriety and correctness of speech share, to some extent, the same opinion, although they feel no special concern as to the final outcome. However, it is reassuring to reflect that the best-informed among us and those whose thorough knowledge entitles them to speak with authority do not take so gloomy and pessimistic a view of the future of the English language. They inform us that the fears of the pedants and pedagogues—the half-educated—are never destined to be realized.

" Strictly speaking," says Professor Lounsbury, than whom there is no higher authority in America on the history of English, " there is no such thing as a language becoming corrupt. It is an instrument which will be just what those who use it choose to make it. The words that constitute it have no real significance of their own. It is the meaning men put into them that gives them all the efficacy they possess. Language does nothing more than reflect the character and the characteristics of those who speak it. It mirrors their thoughts and feelings, their passions and prejudices, their hopes and aspirations, their aims, whether high or low. In the mouth of the bombastic it will be inflated; in the mouth of the illiterate it will be full of vulgarisms; in the mouth of the precise it will be formal and pedantic. The history of language is the history of corruptions—using that term in the sense in which it is constantly employed by those who are stigmatizing by it the new words and phrases and constructions to which they take exception. Every one of us is to-day employing expressions which either outrage the rules of strict grammar, or disregard the principles of analogy, or belong by their origin to what we now deem the worst sort of vulgarisms. These so-called corruptions are found everywhere in the vocabulary, and in nearly all the parts of speech."

Yet the feeling of the pedants and purists reflects the traditional attitude of professional men of letters in respect to the so-called corruptions that have been creeping into English during the last few centuries. It may be worth while to give some of the utterances of our representative English authors on this subject, showing how great solicitude they felt for the purity of our language in consequence of the increasing slang introduced into English. But before doing this, let us make a brief digression, in order to discuss what is meant by slang, which appears to be the source of the alleged corruptions of our speech.

In the first place one must differentiate slang from cant. It is evident, on a careful analysis, that much of the reputed slang now current is really cant, not slang, in the proper sense of the term. Both cant and slang are closely allied and have a kindred origin. This is the reason for the confusion of the two in the popular mind.

Cant is the language of a certain class or sect of people. It is the phraseology, the dialect, so to say, of a certain craft or profession and is not readily understood save by the members of the craft concerned. It may be perfectly correct according to the rules of grammar, but it is not perfectly intelligible and is not understood by the people. It is an esoteric language which only the initiated fully comprehend and are familiar with. For example, the jargon of thieves is called cant, as is also the jargon of professional gamblers. Slang, on the other hand, belongs to no particular class. It is a collection of words and phrases, borrowed from whatever source, which everybody is acquainted with and readily understands. It is not uncouth gibberish intelligible only to a few. It is composed of colloquialisms everywhere current, but homely and not refined enough to be admitted into polite speech. Such expressions may be allowed a place in certain departments of literature, as familiar and humorous writing, but they are objectionable in grave and serious composition and speech.

Now, slang is reputed to have had its origin in cant, specifically 'thieves' Latin,' as the cant of this vagabond class is called. Indeed, this appears to have been the only meaning of slang till probably the second quarter of the last century. In 'Red Gauntlet,' published in 1824, Scott refers to certain cant words and 'thieves' Latin called slang'; and the great romancer seems to have been fully aware that he was using a rather unknown term which required a gloss. Sometime during the middle of the last century, so Professor Brander Matthews informs us, slang lost this narrow limitation and came to signify a word or phrase used with a meaning not recognized in polite letters, either because it had just been invented or because it had passed out of memory. If it is true that slang had its beginning in the *argot* of thieves, it soon lost all association with its vulgar source, and polite slang to-day bears hardly a remote suggestion of the lingo of this disreputable class. In so short a period—but little more than a half century—has the word, as well as the thing it signifies, separated itself from its unsavory early association and worked its way up into good society.

Of slang, however, there are several kinds. There is a slang attached to certain different professions and classes of society, such as college slang, political slang and racing slang. But it must be borne in mind that this differentiation has reference to the origin of the slang in the cant of these respective professions. It is of the nature of slang to circulate more or less freely among all classes of society. Yet there are several kinds of slang corresponding to the several classes of society, such as vulgar and polite, to mention only two general classes. Now, it is true of all slang, as a rule, that it is the result of an effort to express an idea in a more vigorous, piquant and terse manner than standard usage ordinarily admits. In proof of this it will suffice to cite *awfully* for *very,* employed by every school-girl as 'awfully cute'; *peach* or *daisy* for something or some one especially attractive or admirable, as 'she's a peach'; *a walk-over* for any easy victory, *a dead cinch* for a surety, and the like. But it is not necessary to multiply examples of a mode of expression which is perfectly familiar to all. Every man's vocabulary contains slang terms and phrases, some more than others. Often the slang consists of words in good social standing which are arbitrarily misapplied. For although much current slang is of vulgar origin and bears upon its face the bend sinister of its vulgarity, still some of it is of good birth and is held in repute by writers and speakers even who are punctilious as to their English. Some slang expressions are of the nature of metaphors, and are highly figurative. Such are *to kick the bucket, to pass in your checks, to hold up, to pull the wool over your eyes, to talk through your hat, to fire out, to go back on, to make yourself solid with, to have a jag on, to be loaded, to freeze on to, to freeze out, to bark up the wrong tree, don't monkey with the buzz-saw,* and *in the soup.* But of the different kinds of slang and of its vivid and picturesque character more anon.

Let us now, after this digression as to what constitutes slang, return to the former question of the historical aspect of slang, which was engaging our consideration. Though the name is modern, slang itself is, in reality, of venerable age, and was recognized in the plebeian speech of Petronius, the Beau Brummel of Nero's time, whose 'Trimalchio's Dinner' is replete with the choicest slang of the Roman 'smart set.'

The humorous pages of François Rabelais, also, have a copious sprinkling of slang expressions and invite comparison with the productions of some of our own American humorists, who depend not a little upon the vigorous western slang to enhance the effectiveness of their humor. But it is more to the point to cite historical instances among our English authors, especially those who set themselves the burdensome, yet thankless, task of striving to preserve the primitive purity of our speech.

The greatest representative of this number in English literature, excepting Addison, is Swift, the famous dean of St. Patrick's. He was impelled by a desire amounting almost to a passion, it is said, to hand down the English language to his successors with its vaunted purity and beauty absolutely unimpaired. In an essay in *The Tattler* of September 28, 1710, he gives vehement utterance to his feelings on the shocking carelessness and woeful lack of taste in the use of the vernacular exhibited by his contemporaries. He affirms that the conscienceless, unrefined writers of his day were utterly indifferent as to the effect of their deplorable practise upon the future of the English tongue and brought forward, in proof of his contention, numerous examples of solecisms which he alleged were constantly employed, to the corruption and deterioration of the language.

Swift made a threefold division of the barbarous neologisms which were introduced in his day. It is interesting to observe his several classes of these locutions that were contrary to all rules of propriety. The first class was made up of abbreviations in which only the first syllable or part of the word had to do duty for the entire word, as *phiz* for *physiognomy, hyp* for *hypochondria, mob* for *mobile vulgus, poz* for *positive, rep* for *reputation, incog* for *incognito* and *plenipo* for *plenipotentiary.* The second class included polysyllables, such as *speculations, battalions, ambassadors, palisadoes, operations, communications, preliminaries, circumvallations* and other ungraceful, mouth-filling words, which Swift alleged were introduced into the language as a result of the war of the Spanish succession then in progress. His third class embraced those terms which were, to quote his own words, 'invented by certain pretty fellows, such as *banter, bamboozle, country put* and *kidney.*' "I have done my utmost," he pathetically remarks, "for some years past to stop the progress of *mobb* and *banter,* but have been plainly borne down by numbers and betrayed by those who promised to assist me."

Two years later Swift addressed a public letter to the Earl of Oxford, the Lord High Treasurer, deprecating the approaching decadence of the English tongue and earnestly urging some sort of concerted action for correcting and improving the vernacular. The language, the letter recited, was very imperfect and daily deteriorating. The period of its greatest purity, Swift went on to say, was that from the beginning of Queen Elizabeth's reign to the breaking out of the civil war of 1642. His perturbed mind was filled with mingled feelings of grief and indignation as he pointed out in this letter the growing corruptions then so apparent even in the writings of the best authors, and more especially as he was compelled to admit that not only the fanatics of the commonwealth, but also the court itself, had contributed to bring about the sad condition of the language.

It is not worth while to speak in detail of Swift's fanciful and quixotic scheme for purging the language and keeping it pure. But it is interesting to observe, in passing, that his urgent appeal to the prime minister to become the guardian and curator of the English tongue was utterly fruitless and, what is more, that his direful predictions as to the speedy decay of English have never been verified. Furthermore, some of those very neologisms which Swift criticized so unrelentingly are now recognized in polite speech and bear the stamp of approval as the *jus et norma loquendi.* Of his second class of barbarisms well-nigh all are to-day accepted as standard English and are without a trace of slang. With his first and third classes, however, fate has not dealt so kindly, for these words are still under condemnation, save *mob,* which has forced its way to recognition in good usage as a necessary term.

Toward the end of the eighteenth century appeared another champion of the preservation of the purity and propriety of the English speech. This was James Beattie, a learned Scotchman. For some reason or other, the Scotch seemed extremely solicitous about the English language during the eighteenth century—a solicitude that was not appreciated by the British lexicographers and least of all by Dr. Johnson. In a letter written in 1790, Beattie took occasion to speak of the 'new-fangled phrases and barbarous idioms that are now so much affected by those who form their style from political pamphlets and those pretended speeches in Parliament that appear in the newspapers.' "Should this jargon continue to gain ground among us," he assures his correspondent, in a doleful mood, "English literature will go to ruin. During the last twenty years, especially since the breaking out of the American war, it has made alarming progress. . . . If I live to execute what I purpose on the writings and genius of Addison, I shall at least enter my protest against the practise; and by exhibiting a copious specimen of the new phraseology, endeavor to make my reader set his heart against it."

In order to emphasize the damage resulting to the language from the neologisms which were creeping in, Beattie conceived the clever plan of privately printing a series of 'Dialogues of the Dead,' which purported to be the production of his son deceased a few years before. The most interesting of these 'Dialogues' is the report of an imaginary conversation between Dean Swift, a bookseller and Mercury, in which the worthy dean expresses himself as greatly shocked and disgusted at the outlandish English used by the bookseller; and he calls on Mercury to translate the *patois* into good English. In response to Swift's earnest request, Mercury says among other things: "Instead of *life, new, wish for, take, plunge,* etc., you must say *existence, novel, desiderate, capture, ingurgitate,* etc., as—a fever put an end to his existence. . . . Instead of a *new* fashion, you will do well to say a *novel* fashion. . . . You must on no account speak of *taking* the enemy's ships, towns, guns or baggage: it must be *capturing.*" Other words which were censured as improper by this phantom critic were *unfriendly* and *hostile* for which *inimical* was recommended; *sort* and *kind,* in place of each of which *description* was to be used. Some of the locutions then in vogue which especially offended good taste, according to Beattie, were *to make up one's mind, to scout the idea, to go to prove, line of conduct, in contemplation,* and *for the future.* Furthermore, the frequent use of *feel,* which threatened to supplant the verb *to be* in such an idiom as 'I am sick' and drive it from its rightful domain, aroused the learned Scotch purist's apprehension as to the final outcome, as did also the growing tendency to employ *truism* for *truth, committal* for *commitment, pugilist* for *boxer, approval* for *approbation* and *agriculturist* for *husbandman.*

No doubt Beattie believed with Swift that the influx of such pedantic Latinisms as *desiderate* and *ingurgitate* and the like would result in impairing the purity of our speech and perhaps hasten its declension. Nor did he look with favor on the growing fashion to use monosyllables, though of pure Saxon origin, so much affected by some writers during that period. Both of these tendencies were of temporary vogue; yet they served to arouse the fears of the ultra-conservatives as to the fate of the English language. One might suppose that, dreading the then threatening invasion of Latin terms as they clearly did, they would have hailed with delight the revival of Saxon monosyllables as a favorable offset. But even this did not allay their fears and was rather interpreted as a harmful symptom. Time, however, has demonstrated fully that the fears of those purists were unwarranted and that their dire predictions as to the future of English were founded on a very imperfect knowledge of linguistic development. A cursory examination of Beattie's lists reveals the fact that of the verbal innovations and offending phrases which he put under the ban, the genius of the language has adopted not a few, and that, too, without impairing in the least the purity of the English tongue or its capacity for expressing the finest shades of thought. So far from losing, the language has gained in its capacity for expressing nice distinctions of thought and feeling, as a result of its marvelous absorptive power.

It has thus been shown that in the eighteenth century there were not wanting those—purists or what not—who entertained and expressed no little concern as to the ultimate effect upon our speech of the multitude of neologisms and asserted improprieties that were introduced. Did space permit, utterances of a similar character by nineteenth-century writers, from Walter Savage Landor down to critics of far less renown, might be brought forward as evidence to show that the watch-dogs of our speech were as numerous and as alert as ever. Nor is their tribe yet extinct. Ever and anon, even in the last few years, some prophet of evil is heard to raise his voice in vigorous protest against the increasing use of slang as foreboding the decadence of our vernacular. But the warning is not heeded; and the English language, like the real living thing that it is, goes on developing according to the subtle principles of speech development.

The laws governing speech development are very imperfectly known. Consequently none can foretell how a given tongue may develop. The language appears to be independent of one's individual habit of speech; yet it is the sum total of the individual habits of speech that constitutes the language. No man makes a language; no man can make it. Not even the greatest monarch on earth can, by decree or fiat, predetermine the course of development of the language of his subjects. Language is an involuntary product and does not result from any determined concert of action. Yet it is modified and changed by various influences. As long as it is alive and spoken, it is constantly changing and will not remain 'fixed' according to the whimsical desire of the purist. When it ceases to be used upon the lips of the people as a medium of communication of their thoughts and feelings, then it will cease to change and grow and will become 'fixed.' But when a language is no longer spoken, it is characterized as dead. It is in this sense that we call Latin and Greek dead languages, although they survive in modern Italian and modern Greek, respectively.

It follows, therefore, that it is the height of folly for any one, no matter how highly esteemed as an author, to attempt the rôle of reformer of the speech. Such an one is destined to have only his labor for his pains. He can not directly purge the language of its neologisms and improprieties of usage. These violations of standard usage which offend good taste, strange as it may seem, furnish indubitable evidence of the vitality of the speech; for from these contraband expressions come the new terms and idioms which are to take the place of the obsolete words which drop out of the vocabulary.

Viewed in this light, slang assumes a different aspect, and it becomes evident that it performs a certain necessary function in the development of language. It is no longer proper, therefore, to refer to slang with supreme contempt and to condemn it offhand as an unmitigated evil which ought to be forthwith extirpated from the language. For, as an eminent authority has observed, slang is the recruiting ground of language and is, in reality, idiom in the making. It has been pointed out how some of the slang expressions of the eighteenth century which fell under the censure of Swift and Beattie are now found upon the pages of our best authors and are heard upon the lips of our most polished and elegant speakers. Since this is true, no verbal critic can at the present time affirm of a polite slang expression now in vogue that it is destined never to work its way up into good usage, or of a foreign locution that it will never be domiciled in our speech. Nor can he determine, in the case of a new coinage which is a candidate for adoption into the literary language, just when it is taken over from that doubtful borderland between slang and standard usage.

Seeing, then, that slang really has a function to perform in the growth of speech and, therefore, that it is worthy of serious consideration, let us examine some of our modern English slang and study for a short while its origin and history.

Professor Brander Matthews, in an admirable paper on the subject, divides slang into four classes, and we can hardly do better than to follow his general classification. The first class embraces those vulgar cant expressions which are the survivals of thieves' Latin or St. Giles' Greek, and those uncouth, inelegant terms which constitute the vernacular of the lower orders of society. This is the kind of slang heard in the police courts, the kind the newspaper reporter too frequently resorts to, in order to give spice to his account. It has been introduced into literature by some of our recent novelists, notably Dickens. The second class of slang is not quite so coarse, and includes those ephemeral phrases and catchwords which have a fleeting popularity and which, because they meet no real need, are soon forgotten utterly. They live but a day and pass away, leaving behind no trace of their existence. Of this class are campaign slogans and such inane expressions as *where did you get that hat? chestnut, rot, I should smile* and many others equally stupid. It is these two classes of slang that have brought the term into disrepute and merited contempt. For this sort of slang is very offensive to delicate ears and justly deserves the speedy oblivion which overtakes it.

The other two classes of slang, on the contrary, are of a finer type and have a reason for their being, something to commend them to popular favor. It may well be that from this type new idioms and phrases are recruited into our literary language. However, a certain stigma attaches to this better variety of slang, also, in the judgment of many, simply because it is slang. Yet it is heard on the lips of educated and cultured speakers, much to the disgust of those who are fastidious as to the propriety of usage. When it is employed in the written speech, the more careful writers brand it with inverted commas, the barbarian earmarks which attest its social inferiority. Occasionally a bold writer like Mr. Howells breaks down these barriers which convention has set up and gives a polite slang expression the stamp of his approval and authority. In this way these social outcasts, the pariahs of our literary speech, are now and then elevated to the dignity and rank of good society, and finally establish themselves in standard English.

Of these two classes of slang serving some useful end as feeders to the vocabulary and idiom of our language by which its wasting energy is to be repaired, the first embraces those archaic phrases and terms which are revived after long disuse and again brought into service. Restored after several generations of neglect, they now appear to be entirely new coinages and are only received as other probationers. The second class is composed of absolutely new words and expressions, frequently the product of a happy invention and, generally, racy and forceful. As instances of the first class may be mentioned *to fire,* in the sense to expel forcibly or dismiss, *bloody* in the sense of very, *deck* in the sense *pack* of cards and similar historic Elizabethan revivals. Such locutions have a good literary pedigree, now and then boasting the authority of Shakespearean usage. But this is not always apparent and such long-obsolete phrases are, therefore, accounted mere *parvenus.* For example, in King Henry VI. we read:

> Whiles he thought to steal the single ten,
> The king was slily fingered from the deck.—3 Pr., v. 1.

and again in Shakespeare's 144th sonnet:

> Till my good angel fire my bad one out.

The vulgar *bloody,* more common in England than in America, is an inheritance from the classic age of Dryden, who even uses the coarse phrase 'bloody drunk' in his Prologue to 'Southerne's Disappointment.' Swift furnishes a slight variation from this in 'bloody sick,' occurring in his 'Poisoning of Curll.' The more fruitful province of polite slang is the second class which is made up of the clever productions of the present age. It is from the best of these coinages, above all, that the worn-out energies of our vocabulary and idiom are repaired. These raw recruits of slang are severely disciplined and tested by hard preliminary service. If in this test an individual slang expression proves useful and is seen to fill an actual need, it is admitted eventually into the fellowship of standard English. But if, on the other hand, its utility is not established, it is relegated to the limbo of useless inventions where oblivion soon engulfs it.

Let us now review a few specimens of the best type of our modern slang. But perhaps it is safer simply to mention the alleged slang and not undertake to decide which of these expressions are slang and which standard English. For it is no easy matter to trace the line of cleavage between the legitimate technicality of a given craft or profession and polite slang. For instance, are *corner, bull, bear* and *slump,* so familiar in financial parlance, mere technical phraseology or slang? How is one to classify such political terms as *mugwump, buncombe, gerrymander, scalawag, henchman, log-rolling, pulling the wires, machine, slate* and *to take the stump?* If these are mere technical terms, surely *boycott, cab, humbug, boom* and *blizzard* have passed beyond the narrow bounds of technicality and are verging on that dubious borderland between slang and standard English. Furthermore, are *swell, fad, crank, spook* and *stogy* to be considered slang or good English? Each of these terms is supported by the authority of some of our best writers. *Swell,* to cite only one example, is bolstered up by the authority of Thackeray, who in his 'Adventures of Philip' writes: 'They narrate to him the advent and departure of the lady in the swell carriage, the mother of the young swell with the flower in his buttonhole.' Again, how is one to regard *fake, splurge, sand, swagger, blooming* (idiot), *to go it blind, to catch on,* and that vast host of similar racy and vivid phrases which, if slang, still do duty for classic English in common parlance?

A glance at some of our slang idioms shows that they are borrowed from the cant of various crafts and callings. Some are borrowed from the technical vocabulary of the stage, some are taken over from the phraseology of sporting life, while some bear the stamp of various other vocations. Take as an illustration *fake,* or, better still, *greenhorn,* which has forced its way to recognition in standard English. At first *greenhorn* was applied figuratively to a cow or deer or other horned animal when its horns are immature. In the 'Towneley Mysteries' it is applied to an ox, for example. Later it was extended to signify an inexperienced person, or one who, from lack of acquaintance with the ways of the world, is easily imposed upon. The former application where the term was used in allusion to an immature horned animal is a legitimate metaphor. The latter use when applied to an inexperienced person was doubtless recognized as an extension of the metaphor and as slang. But the word filled a need in the vocabulary and was at length admitted into the guild of good usage. Another illustration is furnished by *mascott,* a recent importation from the French. This word originated in gambler's cant and signified a talisman, a fetish, something designed to bestow good luck upon its possessor. The term, despite its unsavory association, somehow has commended itself to popular favor and now seems not to offend the most refined taste. *Slump,* though not so hackneyed, may serve as an example in point also. As a provincialism this word denotes soft swampy ground, or melting snow and slush. Later by transferred meaning it came to characterize in the financial world the melting away of prices, as a slump in the market—a vivid picture which is more interesting as a linguistic phenomenon than as an actual fact.

The history of slang teaches that words, like people, may be divided into two general classes, high and low, or refined and uncouth. "In language as in life," as Professor Dowden puts it, "there is, so to speak, an aristocracy and a commonalty, words with a heritage of dignity, words which have been ennobled, and a rabble of words which are excluded from positions of honor and trust." Now, some writers select only the choice and noble words to convey their ideas, leaving the coarse and vulgar words, terms without a pedigree, as it were, in the bottom of the inkhorn, for those who desire them. Other writers again have less cultured tastes and do not scruple to employ now and then plebeian words, to set forth their thoughts and feelings.

One might suppose on first blush that the dictionary ought to be a safe guide in the choice of words. A moment's reflection, however, is sufficient to convince one that the dictionary can not be relied upon always for this desired knowledge. It is the lexicographer's office to make a complete register of the vocabulary of the language; and so, to make his work exhaustive, he frequently records many slang words in his dictionary. Yet the practise of our dictionary-makers, it must be admitted, varies widely in this respect, some being far more exclusive than others. Our former lexicographers, as for instance Doctor Johnson, exercised a stricter censorship than is the custom at present. But it is not correct always to infer, in the case of an unrecorded word of questionable usage, that the author excluded it of set purpose. It may possibly be omitted from oversight. It seems to be the custom of our lexicographers now to make as complete a record as possible of all polite slang, but to brand it 'slang.' This plan is, of course, altogether distasteful to the pedants and pedagogues who make a fruitless effort to curb and check the vocabulary of a language by rejecting all words of questionable usage. Whatever is not in harmony with established usage, whatever is not authorized by standard speech, the pedants and half-educated utterly reject. Now, heretofore our dictionary-makers have not been entirely above and beyond this narrow and circumscribed view. It was this fact that prompted Lowell, in the preface to his famous 'Biglow Papers,' to express himself in these vigorous words: "There is death in the dictionary; and where language is too strictly limited by convention, the ground for expression to grow in is limited also, and we get a *potted* literature—Chinese dwarfs instead of healthy trees."

The truth is, it does not fall legitimately within the province of the lexicographer to settle the question whether a polite slang term of recognized fitness and utility should be deemed good English or not. No man, however competent a scholar he may be, has the right to determine the growth and development of our language. Yet such a practise means this in the last analysis. There are not a few words and idioms in English that have neither logic nor reason to commend them, but are the product of analogy, as *it, its* and *you,* instead of the strictly correct *hit, his* and *ye,* to use a familiar example; and yet these analogical formations, which at first were mere slang, long ago drove our proper pronouns from the field. This change took place in the last two or three centuries, and that, too, in the very face of the vaunted authority of Shakespeare and the King James Version. No doubt the pedants and purists opposed this change as utterly illogical and contrary to the natural order of development and growth of our English speech; but they were gradually borne down. It is the vast body of those who use the language, the people, not the lexicographers and scholars solely or chiefly, who are the final arbiters in a matter of this kind. It is the law of speech as registered in the usage of those who employ the language that decides ultimately whether a given phrase shall survive or perish; and this is done so unconsciously withal that the people are not aware that they are sealing the destiny of some particular vocable. This silent, indefinable, resistless force we call the genius of the language.

It is hoped that the spirit of this paper will not be misunderstood. The article, let it be distinctly and emphatically stated, is not intended as a brief for slang—far from it. It is written simply to call attention anew to the fact that slang is not to be absolutely condemned as the main source of corruption of our speech, as some assert, but that, contrariwise, it is an important factor in the growth of our vernacular and serves—at least the best of it—a useful purpose in repairing the resulting waste which necessarily occurs in English as in every spoken language.

RECENT ADVANCES IN METEOROLOGY AND METEOROLOGICAL SERVICE IN JAPAN

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TEN years ago, after Japan's sweeping victory over China, the world was awakened to realize that the Japanese were more than yellow barbarians. And only a score of months ago, when Japan made a declaration of war, Russia scoffed at Japan's overtures, and the world pitied her. To the American and the European eye, it seemed like simple suicide for Japan to go to war with the seemingly most powerful nation on the earth. The opinion that Japan would be wiped out of existence once prevailed even in well-informed military and naval circles. Japan has, however, crushed the faith and the fear. She has triumphed so completely that the world now recognizes that this nation possesses a great fighting power and mighty fighting machines. But how few, indeed, realize that, behind this warlike scene, our men of science are industriously and ingeniously attacking great problems of nature, making discoveries and inventions, valuable not only for warfare, but also for the welfare of humanity, and for the progress of science itself. Saying nothing of the knightly spirit of old Samurai, which has been the soul of Japan, the most important factor in the making of new Japan has been her readiness in scientific research and the applications of science to the arts of peace and war. Japan is preeminently a land of science. It is said that there are more people in Japan who read the books of Darwin and Huxley, Spencer and Mill, Faraday and Tyndall, than in England, the land where these great thinkers lived. "What will Japan do after peace is attained?" This question is often asked, and all intelligent Japanese will unanimously answer that "Japan will once more fight a great battle, not naval or military, but intellectual, for the recognition of her scientific achievements in the world."

Elsewhere I expect to give a full account of the recent progress of science in Japan, but my present task is an attempt to give, within a short space, some idea of the Japanese meteorological service* and recent advances in meteorology. One of the Washington newspapers stated some time ago that *even* Japan has a weather-bureau system.

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* A full account of the Japanese Weather Service is given in the monograph, 'The Organization of Meteorological Service of Japan,' published by the Central Meteorological Observatory, 1904.

The fact is that the U. S. Signal Service, which was the forerunner of the present U. S. Weather Bureau, was established in 1870, and that Japan had, as early as in 1872, a meteorological observatory at Hakodaté, and the Japanese meteorological service was organized in 1875, the exchange of international simultaneous reports with the U. S. Signal Office of Washington having been established twenty-eight years ago. The organization of the Japanese Meteorological Service, however, was not completed until a system of weather telegraphy was inaugurated and weather maps with forecasts were printed in 1883.

The Meteorological Service of Japan is placed under the direction of the Central Meteorological Observatory and under the supervision of the Minister of State for Education; it maintains 134 meteorological stations, of which 70 are the provincial stations of the first order, 2 are attached to the Central Observatory, 7 are controlled by the Governor General of Formosa and the rest are the stations of the second order. All of these first and second stations send their meteorological reports to the Central Meteorological Observatory and exchange daily telegrams with the latter. Besides these, there are 1,214 stations of the third order which consists of village offices, district offices, police stations, schools, etc. Each is provided with a set of maximum and minimum thermometers, an ordinary thermometer, rain gauge, etc., and each observer makes daily observations at 10 A.M. (135th meridian time or 8 P.M. 75th meridian time). They send their reports by mail to the respective provincial stations to which they belong.

The stations of the first order make their observations every hour and those of the second order six observations daily. The principal instruments in use at a station are a standard barometer of the Fortin design; a portable mercurial barometer; a psychrometer of August's pattern; a standard thermometer (Cassella or Fuess); maximum and minimum thermometers (Fuess); Robinson cup-anemometer with electric contact device; a wind vane; a rain gauge; and an evaporometer. In addition to these instruments, the stations of the first order and most of second-order stations are furnished with solar radiation-thermometers, terrestrial radiation-thermometers, earth- thermometers for the depths of 0.0, 0.3, 1.2, 3.0 m., etc., and a seismograph of the Gray-Milne type. All these instruments are minutely examined and compared with the standard instruments of the Central Meteorological Observatory. The method of observation and reduction conforms strictly to the decisions of the International Meteorological Committee. The Abercromby-Hildebrandsson classification is adopted for the observation of cloud forms, and the International Meteorological Tables are used for the reduction of observations. For computation of humidity from psychrometric observations, Angot's tables are used. The provincial stations publish monthly and annual reports, and exchange their publications with one another. The employees of the stations consist of the chief, the meteorologists, the assistants and the clerks. The chief and meteorologists are appointed with His Majesty's approval, and the assistants by the governor of the prefecture. Stations are inspected about once every three or four years by the staff of the Central Meteorological Observatory.

The Central Meteorological Observatory of Japan, which is situated at Tokyo, is the center of our meteorological service. Most of the important investigations are conducted by its staff either at this observatory or elsewhere. It is organized into four divisions: (1) cabinet of the director, (2) service of predictions, (3) service of observations and (4) service of statistics. The present director of the observatory is Professor K. Nakamura, D.Sc., a former student of Professor von Bezold at Berlin. The service of predictions has been for the last twenty-five years in the most able and experienced hands of Professor Y. Wada, who is now completing the organization of the similar meteorological service in Korea and Manchuria. Dr. T. Okada now succeeds Professor Wada as the chief of the service of predictions and Dr. W. Oishi is chief of the service of observations at the Central Meteorological Observatory.

The instrumental equipment of this observatory is so complete that it may well be called a meteorological laboratory. Here one can execute meteorological research in barometry, thermometry, hygrometry, nephoscopy, pluviometry, anemometry, actinometry and other lines. There are various instruments and apparatus for verifying the meteorological instruments that are to be distributed to all stations or elsewhere. The observatory also undertakes observations on seismic, magnetic and electrical phenomena. For seismometry, there are the Gray-Milne seismograph, the Ewing seismograph, Tanakadaté's seismograph, the Milne horizontal pendulum, the Omori pendulum. Seismic observation and study form an important feature in the meteorological service of Japan. Each station is equipped with a set of seismographs. Professor F. Omori, of the Tokyo Imperial University, is most active in seismological research, backed by the Imperial Earthquake Investigation Committee, which is composed of such eminent men as Baron Kikuchi and Professor Tanakadaté. For further information along this line of work, the reader should consult Baron Kikuchi's monograph, 'Recent Seismological Investigations in Japan,' which was originally prepared as an address to the International Congress of Arts and Science (in 1904) at St. Louis. For the measurement of atmospheric electricity, there are used at the Central Observatory Exner's portable electrometer, Mascart's self-registering electrometer, Kelvin's collector, etc. The hourly values of electric potential are published in the annual reports.

The periodic publications of the Central Meteorological Observatory are the daily weather-map, the monthly report, the annual report and the monthly weather review. In addition to these, the *Bulletin of the*

Central Meteorological Observatory is published in foreign languages. This contains the results of investigations of meteorological and allied problems.

Turning from the practical to the educational side of meteorology in Japan, we find that in the College of Science of the Tokyo Imperial University a chair for meteorology has recently been established in the department of physics. In the College of Agriculture of the same university Professor Diro Kitao has been giving excellent lectures on meteorology for the last twenty years. Lectures on the same subject are also given by Professor Goto at Tokyo Higher Normal School, by Professor Baba at Tokyo Navigation School, by Professor Y. Wada at the Naval School and by Dr. Inagaki at Moriaka Higher Agricultural School. It is also to be understood that meteorology is taught in all other schools of agriculture, navigation, commerce and technology, as well as in military and naval academies. At the Central Meteorological Observatory a temporary school is opened every year for the training of meteorological observers at provincial stations. The term of this school is usually six months, during which period are given courses of lectures on meteorology, seismology, physics, instruments and methods. This temporary school has been an important factor for securing a uniformity and a higher standard in the attainments of observers.

The most convincing evidence of the popular interest in our science is the fact that Japan has supported the Meteorological Society of Japan for more than twenty years. We understand that meteorology has no recognized place in such a popular gathering as the American Association for the Advancement of Science, and that the *American Meteorological Journal* was long since discontinued. The Meteorological Society of Japan is composed of two hundred and sixty-four active members, only three being honorary. This society publishes a monthly journal, partly in Japanese and partly in foreign languages. At its general meetings held annually in May meteorological papers are read and discussed.

So much for Japan's contributions to practical meteorology and its diffusion. Now let us examine what has been done by Japanese meteorologists for theoretical meteorology. Any one who has paid close attention to meteorology must be aware that the progress of this science lags far behind that of some other physical sciences. Within a century the world has seen astronomy, physics, chemistry and other well recognized sciences emerge from their previous uncertain and indefinite condition; but meteorology is at present inchoate, and its ascertained facts are too scanty to allow of organizing any system of fundamental principles. Fifteen years ago, von Helmholtz turned his attention to the hydrodynamics of the atmosphere, but, so far as meteorology is concerned, this great man left his work unfinished. Recently theoretical researches have been undertaken by von Bezold, Neuhoff, Brillouin, Pockels, Margules, Sprung, Bjerknes, Bigelow, Wild, Pernter, Ekholm and many others. It appears, however, that not very much has been added to dynamic or theoretical meteorology since the publication of the works of Ferrel, Mohn and Oberbeck. The present status of the science being such in the professed countries of science, Japan can not be criticized if she has not done very much towards developing theoretical meteorology. She may, however, be proud of Professor Diro Kitao, a profound mathematician, and of his work, comparable with the elegant analysis of Oberbeck and Helmholtz, in fact, reminding us remarkably of the work of Kirchhoff. While Japan was still in the national turmoil of forty years ago, Diro Kitao was sent by the government to Germany for study. He went through the gymnasium at Berlin and studied mathematical physics at Berlin and Göttingen. After an absence of about sixteen years, he returned to his native land and in 1886 was appointed as professor of physics at the College of Agriculture of the Tokyo Imperial University. Professor Kitao has published many important memoirs, the most noteworthy of which is his 'Beiträge zur Theorie der Erdatmosphäre und der Wirbelstürme.' This work was published in three volumes, volume I. in 1887, volume II. in 1889 and volume III. in 1895, in the Journal of the College of Science of the Tokyo Imperial University. This most elaborate memoir covers some four hundred pages. On account of its great length and of its highly mathematical nature, it is impossible to reproduce here all its important results; but it may be worth while to give here the title of each part. The first volume contains the introduction and the discussions of hydrodynamic equations with consideration of the earth's rotation; the general differential equations for the motion of the atmosphere; the general relations between isodynamic lines, wind-directions and vortex-axes; space integration; the equations of atmospheric motions under special assumptions; vorticular motions of the atmosphere; circular cyclones and anticyclones (§ I.–VII.). The second volume, including § VIII.–XI., treats of a vortex field of rectilinear isobars; the formation of complex vortices in the atmosphere; special motions in a vortex-field; the change of wind-direction, strength and pressure for a given external point in the case of a double vortex formation. The third volume treats of the condition for a stationary vortex when two vortices exist; vertical atmospheric circulation; variable vortex formation in the atmosphere (§ XII.–XIV.).

Several important meteorological memoirs have been published, mostly by the members of the Central Meteorological Observatory. Among these we note 'Sur la marche diurne de la température de l'air,' by Nakamura; 'Studies on Atmospheric Electricity,' by Homma; 'Earth Temperature at Tokyo,' by Oishi; 'Température moyenne annuelle de la température de la mer dans l'Océan Pacifique Occidental,' by Wada. Okada has published several papers on the evaporation in

Japan, on the underground temperature at Nagoya and Osaka and on the thermal conductivity of snow. Among the papers officially published by the Central Meteorological Observatory are 'Typhoon of September 13–14, 1881'; 'Typhoon of September 26–27, 1881'; 'Forms of Clouds'; 'Some Researches on Agricultural Meteorology'; 'Typhoon Tracks in Japan'; 'Low Pressure in Japan'; 'Normal Pressure, Temperature and Rainfall in Japan,' etc. Since 1880 the Central Meteorological Observatory and some provincial stations have made several meteorological expeditions to high mountains in various parts of Japan to investigate the atmospheric phenomena and processes in the high strata. The results of these investigations have been published in several volumes. There may be, besides, many important meteorological papers and books written in Japanese that have not come to the notice of the present writer, who has been absent from the country for many years.

The preceding paragraphs show how excellent is the work that Japan is doing for the progress of theoretical as well as practical meteorology. A glance at a map of the Orient will clearly show how serious and difficult a matter it is to predict weather in Japan. Japan stands under the direct influences of the Pacific Ocean and the Asiatic continent, and also of the tropical and polar ocean currents, so that meteorological as well as climatic conditions in Japan are very complex. Very often a continental cyclone and a typhoon which, of course, comes from the tropics, pass through Japan simultaneously, thus bringing complexities to the weather. In spite of all these difficulties, storm tracks and other meteorological conditions have been very carefully investigated and the daily predictions that issue from the Central Meteorological Observatory are said to be most trustworthy. Our meteorological service has recently extended to Korea and China. Under the charge of Professor Y. Wada, five stations have just been completed in Korea, the Chemulpo Meteorological Observatory being the center of the system. Several stations have been established in Manchuria, and it is said that a large magneto-meteorological observatory is now planned to be established in Pekin by the government of Japan. As the writer has already described in *Science* (July 28, 1905), the establishment of the Mt. Tsukuba Meteorological Observatory by His Imperial Highness Prince Yamashina is another great advance. All these material items together with the alertness and native ability of Japanese meteorologists give assurance that she will make great contributions to the dynamics and physics of the earth's atmosphere and to the allied sciences in general.

WITH THE BRITISH ASSOCIATION IN SOUTH AFRICA.[1]

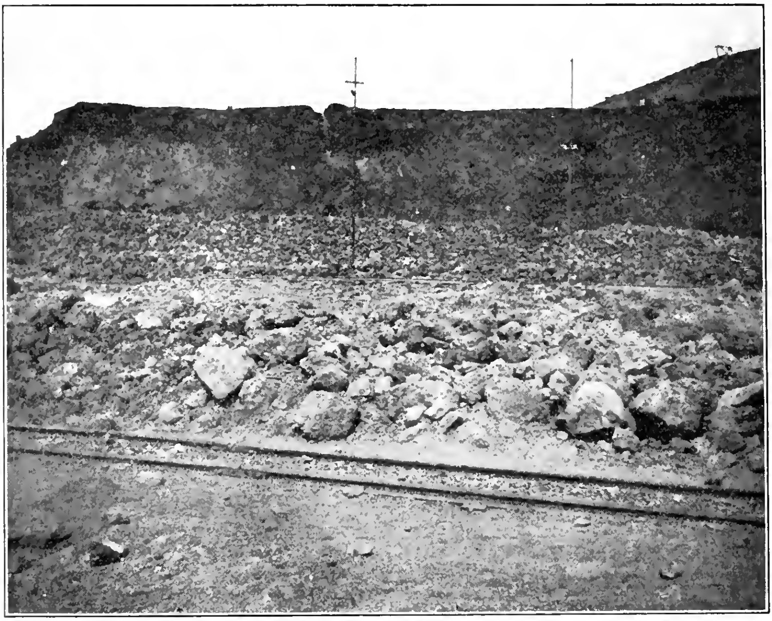
BY PROFESSOR ERNEST W. BROWN,
HAVERFORD COLLEGE.

V.

PRETORIA, the capital of the Transvaal, presents the greatest contrast to its ambitious neighbor forty-five miles away. Although it is 4,500 feet above sea level, nearly the average of the rest of the colony, the hills which surround it give the impression of a rather low situation, but it loses nothing from the numerous blue gums, willows and other trees which are to be found everywhere in the city. The chief interest to a visitor naturally arises from its past history and its connection with the last president of the South African Republic. The fine Parliament House and Law courts are imposing beside the many one-storied houses which constitute the greater part of the town; near-by are Kruger's house and the church which he attended. In spite of the fact that Pretoria was down on the program only as an excursion from Johannesburg, its residents were not behind those of other towns in making hospitable arrangements for such as were able to take advantage of them; perhaps the most fully appreciated was a cross country 'Trek' to Mafeking which will presently be described.

A few miles to the north lies the new Premier Diamond mine, a wonderfully rich pipe of yellow, red and blue ground which a short time ago produced the largest stone ever discovered. It is less than three years since the place was bare rolling veld; now there is a hole over seventy acres in extent and forty to sixty feet deep surrounded by machinery and a high barbed-wire fence. The statistics given to us showed that already more than a million carats of diamonds have been taken out and that test borings down to a thousand feet exhibited ground similar to that near the surface. An invitation from the management to lunch and to an inspection of the mine was accepted by at least a hundred and fifty members. It was amusing to be with and to watch the party, guided by Mr. Cullinan, the original discoverer, and his staff, wandering through the diggings and examining the ground, evidently in the hope of discovering another Cullinan diamond; and later crowding round the tables on which the concentrates were spread for examination—the stage where mechanical treatment ends and hand labor begins—and picking out a few small stones. This final process is shortly to be replaced by a mechanical one based on the fact that the diamond seems to be the only stone which will stick to a bed of grease when a pan of 'concentrates' (the remainder after all the earth and lighter material have been washed out) is passed over it with a properly adjusted flow of water.

A cross country trek from Pretoria to Mafeking seemed to offer greater attractions than the 882 miles of rail which separate those places, in spite of the fact that Bloemfontein and Kimberley would thus be omitted. At present there are no rail connections between the two trunk lines going north from De Aar Junction (which lies just south of the Orange River), although Klerksdorp, the terminus of a branch line from Johannesburg, and Mafeking, on the Cape-Bul-



SPOT (in the bank near the telegraph post) WHERE THE FAMOUS CULLINAN DIAMOND WAS FOUND.

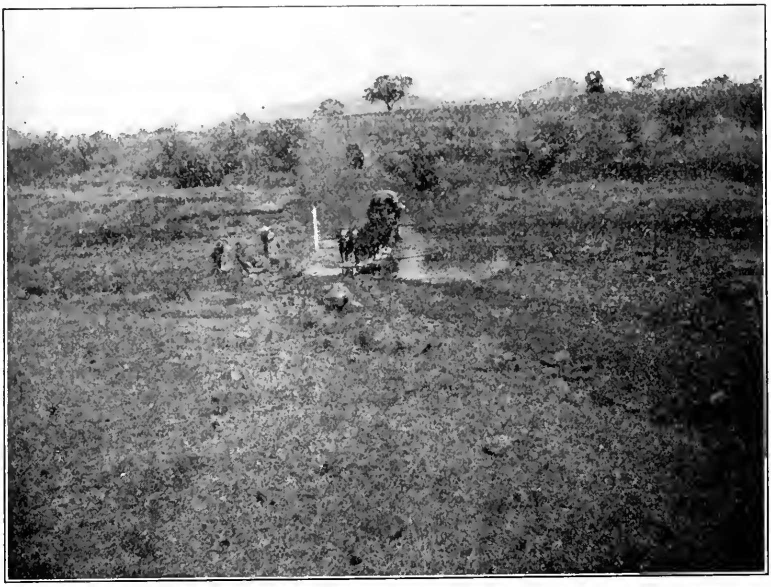
awayo railroad, are only 93 miles apart. These connecting links are of course valuable for opening up the country through which they pass, but it is difficult to get a return on the capital laid out where the chief traffic is to and from the coast and not an exchange between inland centers. But it is hoped that the time is not far distant when the farms in this district may furnish regular supplies to the large towns and make them independent of imported food produce. Railways are already projected from Pretoria to Rustenburg, sixty miles to the west; and also from Klerksdorp to Fourteenstreams which lies on the Cape-Bulawayo railway, 140 miles to the southeast, thus making the first connection between the two trunk lines north of their branching point.

VI.

The route chosen for the journey to Mafeking by road lay through 180 miles of some of the most fertile districts of the Transvaal and included nights spent at the small towns of Rustenburg, Zeerust and Ottoshoop. Two stage coaches, each capable of carrying eighteen passengers with baggage, and a large ambulance wagon were provided for the accommodation of the party which, with guides and leaders, numbered thirty. These coaches have of course been gradually supplanted by railroads where there was sufficient traffic to justify a regular service, but they are still in use in Rhodesia. As the illustration

AN IRRIGATION DAM AND TRENCH ON MR. GINSBERG'S FARM. (Photo lent by Mr C. G. Darwin.)

shows, they are of the Concord type and indeed those which actually conveyed us were built in the United States. Six pairs of mules were harnessed to each coach. We were accompanied throughout by Messrs. H. H. Hewson, W. D. Sievwright and G. W. Herdman of Pretoria, and it was mainly owing to their care and thoughtfulness for our welfare that no serious mishap occurred during the six days' trek. The magistrate of each urban district through which we passed also joined the party, while it traveled through his territory, and much was learnt of the land and its people from these gentlemen and from residents whom we met along the route from time to time. The limits set to this article forbid more than a brief account of the general impressions gained. It must suffice to mention that the first night we camped

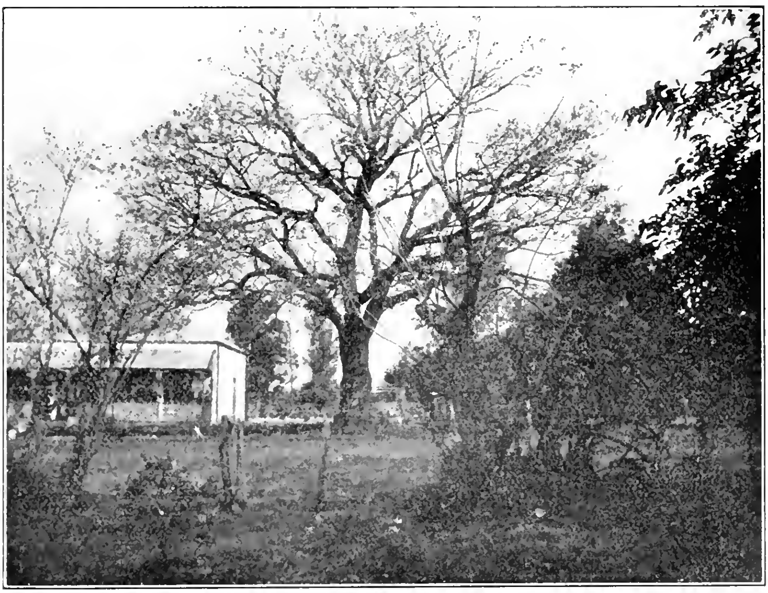


Crossing a Drift.

luxuriously on Mr. S. Ginsberg's farm as his guests, the camp having been provided by the Royal Engineers, and the next morning wandered over the farm inspecting the experimental growing of tobacco and oranges and an irrigation trench, some two and a half miles long, carried round the side of a hill. Another night we slept on the open veld wrapped in blankets and rugs. Our experience of the hotels at the three towns mentioned above was a favorable one; they have nothing to lose by a comparison with those in places of a similar size in either Europe or America.

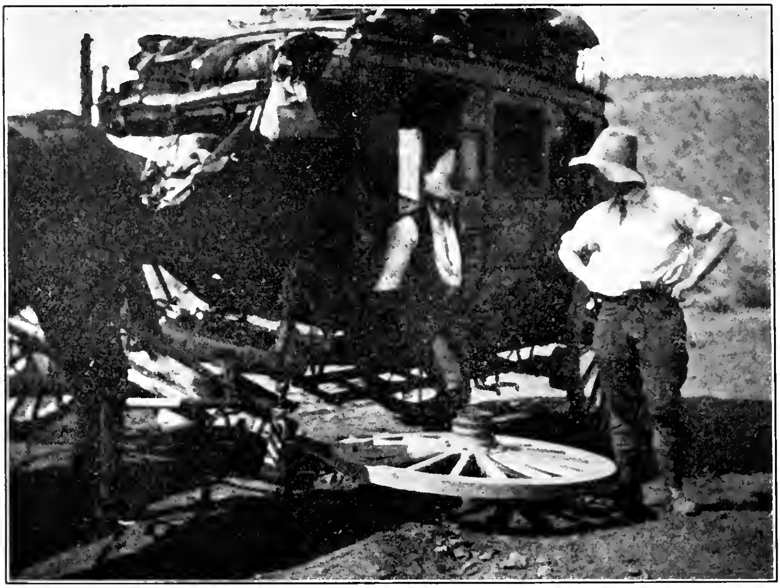
The government is carrying on the work of improving the main roads in farming districts by building bridges over the deeper 'drifts' (fords where the rivers can be crossed), by metalling the surfaces, and by digging side trenches to carry off the torrential rains during the wet season. This is in line with the policy of developing the agricultural possibilities of the Transvaal through an increase in the facilities for getting the produce to a market. But the difficulties of raising it are many. The cattle have been nearly exterminated by war and disease; to prevent the spread of the latter in future the farms are being accurately surveyed and surrounded by barbed-wire fences. The raising of crops with any regularity seems to require expensive schemes of irrigation and the construction of dams to store the water, but it is by no means certain that these schemes can be made to pay their cost. Tobacco growing has long been fairly successful in some parts and the leaf finds a ready sale. Some fruits, especially oranges, can be also grown with success where the farmer has sufficient capital to await the time necessary to get a crop, but the cost of transportation prevents export in competition with the fruits produced in other parts of the world. It is well known that a great effort has been made by the government to get the Boers back on their farms, and we saw one example of this in the new houses which have been built near the roofless walls of every old one that we passed. For the Dutch settler is in general the only class which has so far succeeded in extracting a living out of the land, partly owing to his few needs and his content with meager surroundings, but he is in some ways an obstacle to development by his constitutional dislike to any alteration of the methods handed down to him from his ancestors.

On every side were to be seen evidences of the long-continued guerilla warfare; block houses perched on the hills, sometimes in long rows a mile or two apart, at other times in isolated places; an occasional area covered with rusty tin cans showing where a concentration camp had been situated; skeletons of cattle and mules along the roadside; an acre of the whitened bones of oxen, the scene of the destruction of a convoy caught in a trap. Many of the pleasures and troubles of trekking were experienced. The night under the open sky on the veld, various breakdowns and minor accidents, the hot noon suns and cold starlit skies, the clouds of red dust raised by the mules—all combined to give some idea of that fascination for traveling in Africa which has so often been the theme in stories of fact and fiction.



TREE IN RUSTENBURG UNDER WHICH THE LATE MR. KRUGER PREACHED HIS FIRST SERMON TO THE BURGHERS.

Mafeking has little of interest for the ordinary sightseer and nothing remains of its spectacular siege except a few banks on the flat plain showing where the trenches had been placed. The native 'staadt' contains some five thousand blacks living in huts and houses of sun-baked bricks and plaster, with occasional corrugated iron roofs. The special train only stopped here long enough to gather up those who had come by road from the Transvaal. All the following day was spent in running along over the brown veld, sometimes flat and bare, sometimes covered with thick bush, but generally rolling country dotted with trees and intersected here and there with the dry beds of



AN INCIDENT OF OUR 'TREK.'

streams. At this season of the year the ground has become parched under the hot sun and long coarse dry grass covers the whole face of the country. A tree with a straight trunk is rarely visible and the twisted branches were devoid of foliage except where parasitic growths, frequently species of misletoe, showed their bright green stems. All the way from Durban to the end of our ride, grass fires, started by the farmers to clear off the ground before the rains, were visible and often made the nights picturesque as they slowly burned their way in long lines over the plains and hills.

The standard South African railway gauge is forty-two inches, fourteen and a half inches less than the ordinary one. This is probably an economical width for the present needs of the country, but it introduces difficulties in the construction of comfortable sleeping accommodation. The present type of car used on the Cape government railways has a very narrow side corridor from which open compartments, each containing four berths, two upper and two lower, transverse to the length of the car. These berths are rather short for one a little over the average stature, and the lavatory accommodation is somewhat limited. But the dining cars provide excellent meals at two dollars a day and this in a country into which much of the food is at present imported must be considered very moderate, especially north of De Aar Junction. The new cars on the Natal railways are, however, of a much more roomy and convenient type. It was in special trains made up from these cars that the majority of the members of the association was to spend most of the two weeks following the departure from Johannesburg. The life on board was not uncomfortable, and there was plenty to interest in the views which successively passed before us as we steamed along at fifteen to thirty miles an hour, or in discussions on what we had seen and heard. Then at every stopping place, and these were not infrequent for taking water or coal, the zoologists swarmed from the train with nets and snared every insect within a radius of two hundred yards, and the geologists with their hammers gathered in treasured specimens of rocks. The engineer became skilful in solving the problem of gathering up the passengers and not wasting time in waiting for the laggards, by steaming so slowly out of the way side stations that any one not more than a hundred yards from the train when it started could easily get on board.

VII.

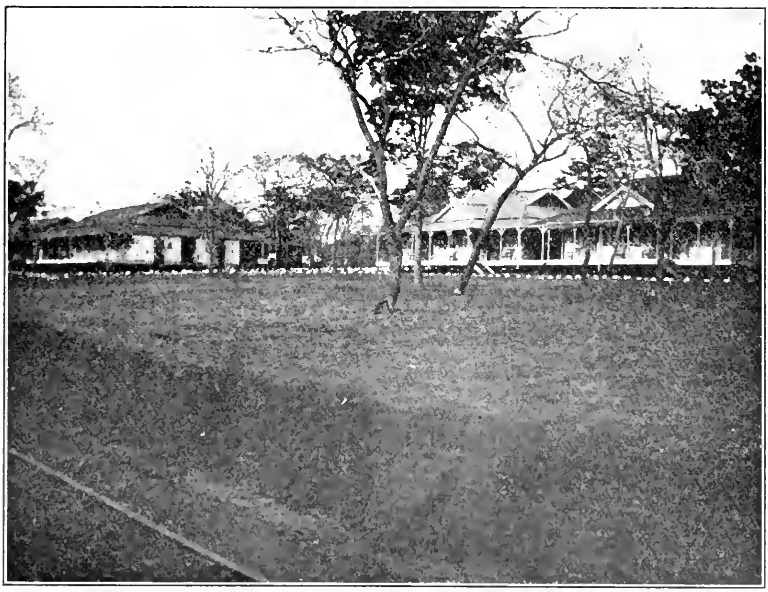
Bulawayo, the principal town in Rhodesia, exhibits strongly the large ideas of Cecil Rhodes and his confidence in the future. Laid out in blocks, with streets far wider than one finds even in the most modern towns, its principal buildings in the center near an immense market square, Bulawayo is prepared for development to an extent which seems to be out of proportion to its needs for many years to come. At the present time there are many inconveniences in having the town so widely spread out, and the expense of running it is not small. Except in the center, one can drive along roads with name posts at every corner, but not to be traced otherwise than by wheel tracks in the yellow dusty ground. Rhodes's house, presented by him to the government, is situated on a hill three miles from the town and is connected with it by a perfectly straight and broad road planted with a double avenue of trees. A better method could hardly have been devised for enhancing the dignity of the approach to his residence or for striking a note in his character—the direct route to his objective and a well-marked way for those who should follow in his footsteps.

The Principal Street in Bulawayo.

The poetic side of his nature is shown in his choice of a final resting place. From a point twenty miles along the railway south of Bulawayo a branch line runs towards the Matopo hills where he had a large estate. A drive of eight miles from the hotel at the terminus leads into wild scenery along gradually ascending valleys, past large enclosures containing wild animals and through a park which is being continually improved by the planting of trees and all kinds of flora. On either side the road is flanked by hills which seem to have been built up by Titans who piled up rocks and boulders in every conceivable position, perching them on the tops and sides of smooth turtle-back shaped rocks five hundred feet high, or dropping them on the plain and covering them with bushes and trees. As the 'Roof of the World' is approached, the carriages are left and a footpath ascends gradually over smooth rock on to the flat top of one of the highest of the hills—the 'World's View.' On this spot, enclosed by a circle of boulders some fifteen or twenty feet high, is placed the grave dug out of solid rock and covered by a plain slab bearing only the simple inscription, 'Here lie the remains of Cecil Rhodes.' A not unpleasing contrast is afforded by an elaborate monument nearby erected to the memory of Major Wilson and his comrades who fell at the Shangani River on December 4, 1894.

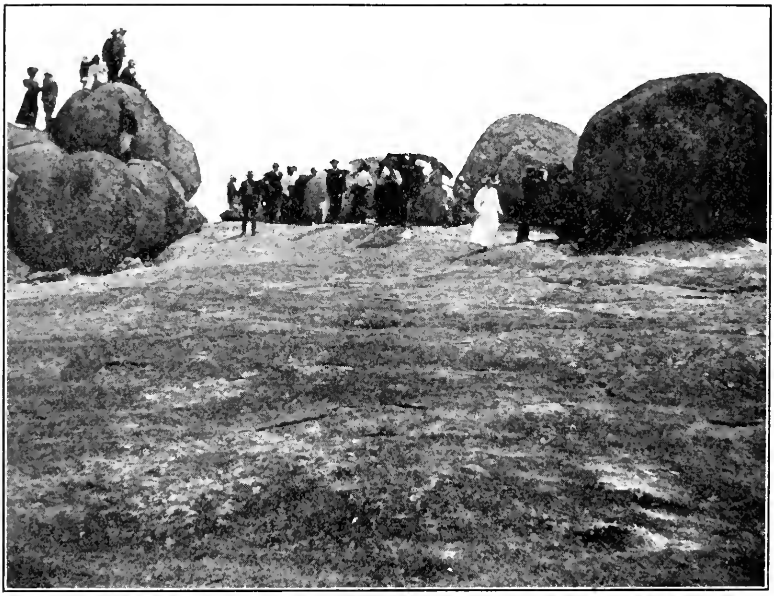
This large estate was owned by Cecil Rhodes and was left by him under the care of the trustees for the benefit of the public, full directions being given in his will for improving the property with the help of funds which he designated for the purpose. One can not travel through Rhodesia or indeed through any part of South Africa without feeling how strongly the ideas of this one man have dominated and still largely determine the development of the country. Whatever we may think of his career, we are forced to admit that the reverence felt for him and his opinions by those who worked with or under him mark him out as a personality of unusual force. He inspired too an enduring belief in the future of Rhodesia, and this in the face of almost every difficulty that a new country has to undergo. Against the condemnation of some of his actions at the bar of public opinion is to be set the opinion of those who knew him and who believe that he acted consistently with a high standard of his own and that at his early death the British Empire, and perhaps the world, lost one who might have achieved a foremost place in the history of nations.

The Victoria Falls on the Zambesi river lie 282 miles to the north-west of Bulawayo. The curious box-like formation into which the water drops with the lip over a mile long and the opposite ground on the same level and not more than 150 yards away, gives unusually fine points of view and permits every part of the falls to be seen. When the water is low, as was the case at the time of our visit, one can see down to the bottom of the chasm 400 feet below; or cross over to the islands above and look down into the depths from the uncovered rocks with the water tumbling down close by. The river leaves the 'box' by



HOTEL AT THE VICTORIA FALLS.

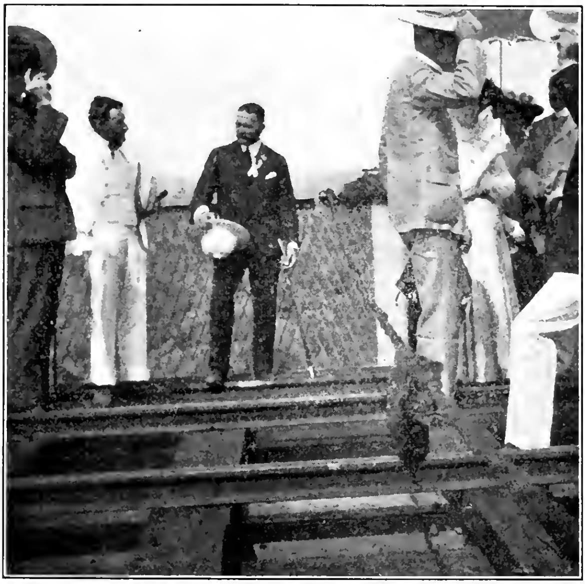
a narrow opening some distance from the middle of the long opposite edge, and pursues its way through a deep gorge which winds to and fro like the strokes of the letter W several times repeated, showing clearly the successive stages by which the river bed has burrowed its way through the country. The 'rain-forest,' a thick mass of trees and undergrowth, and the Palm Kloof, a ravine leading down to the bottom of the gorge, are kept moist by the shifting masses of spray. Above the falls, the banks are clothed with tropical vegetation and the long reaches of apparently calm but swiftly flowing water show little of the many hidden dangers which small craft passing along them must avoid. The marvels of nature are perhaps equalled by those of civilization.



THE 'WORLD'S VIEW'

Ten years ago not more than thirty white men are known to have visited this spot since its discovery in 1855 by Livingstone, and last year it was connected with Bulawayo by rail. The line has now been carried over the gorge just below the falls by a bridge 650 feet long and 350 feet above the water, finished last spring; it is being continued now to Lake Tanganyika, and had in September reached a point 160 miles from the Falls towards this objective. Perhaps the greatest marvel of all, as Professor Darwin remarked in opening the bridge to passenger traffic on the morning of September 12, was that his speech on that occasion should appear in full in the London afternoon papers of the same day.

Tourists will now find no difficulty in reaching the Falls nor will they need to expect discomfort while staying there. The hotel, about a mile from the principal points of view, supplies food and lodging on much the same scale as those in other parts of Rhodesia. Perhaps the greatest satisfaction on arrival is the absence of any feeling of disappointment, however much one may have heard or read of the beauty and magnitude of the falls, and civilization has so far done nothing to spoil the views. Mr. F. W. Sykes, who has been appointed conservator by the Chartered Company, has constructed paths so that visitors may approach every point of view and enjoy the scenery without the encumbrance of a hired guide. The new bridge rather adds to the effect than otherwise: as one descends to the bottom of the gorge amidst the



THE PRESIDENT OPENING THE BRIDGE.

trees and undergrowth in the Palm Kloof, its graceful arch gives the eye a resting place near the top and assists one to appreciate the height of the rugged vertical cliffs. I understood that the power house is to be constructed at the foot of the second bend of the gorge, the water being conveyed from above the falls by a tunnel or canal, so that nothing of it will be visible from the usual points of view. It is intended that no new buildings shall be placed on the general level of the land within a radius of a few miles and plans are even in existence for moving the present hotel further away. As to the available energy for commercial purposes, the latest estimates give a minimum of 300,000 horse-power at low water as against 5,000,000 at Niagara; but after the rains there would be many times this amount so that even if the minimum

Rainbow seen looking along the Falls from near the West End.

Part of the 'Main Fall' from Livingstone Island.

should be wholly employed, the spectacle at full flood would not be very seriously affected. The opinions of the residents as to the best time for a visit are divided. Some preferred August and September when the water is low and the air comparatively clear of mist; others recommended January and February for seeing the huge masses of water which then cover nearly the whole width of the lip but which can only be seen in glimpses as the spray shifts about.

VIII.

On the return to Bulawayo, the east and west coast parties separated, the latter going direct to Cape Town and thence home. The rail journey to Beira on the east coast was broken at Salisbury and Umtali. Both of these towns are situated in or near gold-bearing districts. The region is interesting too to ethnologists on account of the ancient ruins to be found at Zimbabwe and elsewhere, but it was sad to learn that all the later evidence so far obtained has destroyed any connection between Rhodesia and the land of Ophir. The party, now reduced to two hundred, was entertained at Salisbury and Umtali by the residents to lunch; and similar hospitality was shown by the governor, the Portuguese officials and the Mozambique Company at Beira. Our debt of gratitude to these three towns is the greater for the trouble and expense to which the small number of residents had put themselves, although our stay in each had to be limited to only a few hours; there was no chance to make even the small return in our power by giving lectures or by learning, except in conversation, of the development of the districts round these recent settlements.

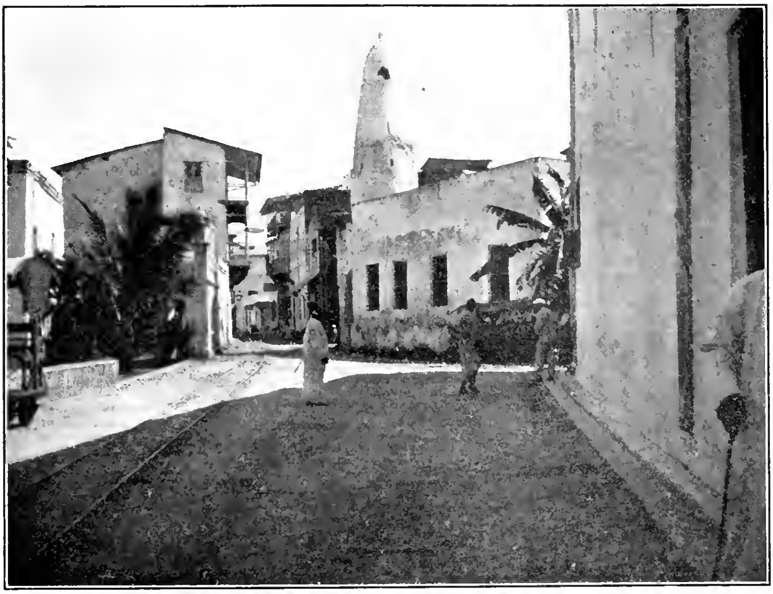
A few concluding words on Rhodesia must suffice. The details of its administration and development by the British South Africa Chartered Company are to be found in the published reports and circulars of the company. As to its possibilities, I can only give here, with all reserve, my own opinion formed on what I saw in the rapid journey or learnt in several conversations with various officials and others. In its general characteristics, the country does not appear to differ greatly from the Transvaal. But it seems to have rather better advantages. Its soil is perhaps more fertile, its rains more certain and droughts less frequent. The mineral wealth is considerable: there are excellent coal seams, a rich copper mine and, if the present prospects are fulfilled, valuable gold fields. A magnificent river flows through the country, adapted at the Falls to furnish power for all purposes in the driest season and possibly available in the future for irrigation if necessary. An unbounded enthusiasm and belief in its future amongst those who are administering its affairs there are not amongst the smallest of the assets of Rhodesia.

The 'Durham Castle' left Beira on September 17. A brief call of a few hours was made at the low island built of coral on which Mozambique stands. The town is picturesque with its square topped houses and walls washed a bright red, yellow and light blue, the native huts of bamboo thatched with palm leaves, and the numerous palm trees growing everywhere. A stay of a day and a half allowed us to see Mombasa, to make purchases in its native bazaars, and to take a journey by train to Mazeros, fourteen miles up into the country. The town is close to the equator and we saw luxuriant tropical vegetation, cocoanut and other species of palms, and the huge squat trunks of the baobab—a pleasing contrast after our long experience of the dried-up veld. Leaving there, eleven days of burning sun and hot stifling nights in the Indian Ocean, across the gulf of Aden and up the Red Sea whose waters one day showed a temperature of 92° Fahrenheit, brought us to Suez. After a week in Egypt necessitated by the block in the Canal, the ship left Port Said for Marseilles where many landed in order to reach England rapidly. The remnant, passing through the Straits of Gibraltar and crossing the Bay of Biscay, disembarked at Southampton on October 24.

The one sad incident which occurred during the tour was the illness and death of Sir William Wharton, at Cape Town, after our departure from Beira. His work and scientific attainments will find a more fitting record elsewhere. Those who had learned to know him as a fellow-traveler can readily understand and sympathize with the sense of loss experienced by his family and many friends. As I revise these lines comes the news of the death in Cambridge of another member of the party which will not be less severely felt, Sir Richard Jebb, perhaps the most distinguished scholar of his day and a leading authority on educational questions. One rarely talked with him without drawing something interesting from his great store of knowledge and he added much to the success of the meeting and the pleasure of the voyages by his presence amongst us.

IX.

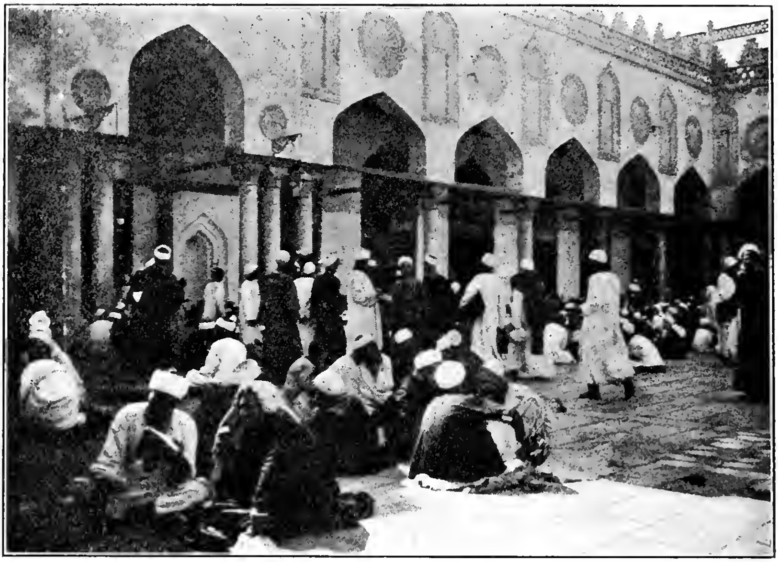
It is almost impossible to sum up in a few sentences the wealth of impressions received during the five weeks in South Africa and the subsequent brief visits in East and North Africa. A 'gigantic picnic,' as Professor Darwin characterized the tour in one of his speeches, it truly was; but it was also a 'scientific picnic' with wonderful opportunities for profit to those who wished to take advantage of them. The various handbooks, specially prepared for us, on matters connected with the colonies, the arrangements made for seeing everything without waste of time and with the minimum of trouble, the way in which all the people put themselves at our disposal whether for showing the country or for telling what they knew—all helped to make the experience no ordinary one and enabled us to carry away facts and ideas which could hardly have been obtained in a much longer period. To those who are accustomed to travel in Europe and who have money and leisure for four months or more away from home, a visit to South Africa is to be highly recommended. The steamers, while not equipped with the excessive luxuries of the most modern North Atlantic boats, are comfortable and sail over waters which are rarely disturbed by storms or gales. The long distance trains are at least as good as those in Europe, and hotels, accustomed to cater for English people, will be found everywhere. The cost of such an expedition extended



A Street in Mombasa.

over four months need not exceed fifteen hundred dollars per head, including passage money.

Finally, what should South Africa hope to receive in return from those who have accepted her hospitality? An increased sympathy with her people, a better knowledge of their struggles in developing the resources of the country, and an attempt to put an end to the long career of misrepresentation which has been pursued by many public bodies and private individuals in the mother country, doubtless. But there is more. The colonies are not lands where the agriculturist can simply sow his seed and watch his crops grow; where the rancher can stock his farm and await the increase; where the planter puts in his trees and leaves them until the harvest is ripe; where the miner has only to dig out the gold and grow rich quickly; or where the trader can take his goods and calculate his profits beforehand. Irrigation, and, in many cases, fertilization of the soil, are generally necessary for obtaining a moderate crop; cattle must be protected from the parasites and diseases which carry them off wholesale; the planters must make many experiments to find suitable trees and then discover a market for his fruits; gold digging can only be made to pay by companies with large financial resources employing the most modern scientific methods for the extraction of the metal; and the trader is handicapped by the cost of transportation and the small demand for his goods. These are some of the problems which the colonist asks his visitors with their store of knowledge to help him to solve: he needs every device which science can furnish to enable him to exist. Further, his land has been



INSIDE THE MOHAMMEDAN UNIVERSITY IN CAIRO. (Photo lent by Mr. C. G. Darwin.)

lately rent by civil war, and two white races with totally different ideals must live side by side working together for the common good: the black races, far outnumbering the settlers, present problems at least as difficult as those we have to deal with in the United States. He asks too for help in building up schemes of education for both black and white, and these schemes must include primary and secondary schools, colleges and universities for the study of the humanities and pure science, and, what is perhaps more important than all for the prosperity of the colonies at the present moment, institutions where elementary and advanced technical education in all its branches can be obtained. If any help is forthcoming towards the solution of these questions, South Africa will feel well repaid for her hospitality and will consider that the visit of the British Association to her shores has not been in vain.

SOME RECENT TENDENCIES IN MATHEMATICAL INSTRUCTION

By Professor G. A. MILLER
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SEVERAL prominent writers have suggested that 'pure mathematics' should be called 'free mathematics' in view of the great latitude of freedom both in subject matter and in methods of work.[1] This view is diametrically opposed to the one commonly held. The student of elementary text-books on mathematics can not fail to be impressed by the close similarity in subject matter and in methods. In our arithmetics and algebras we find problems which are quite similar to those in the work written by Ahmes, an Egyptian priest living seventeen hundred years before Christ. Our geometries bear such a close resemblance to Euclid's, written three hundred years before Christ, that the terms Euclid and elementary geometry are still practically synonymous in the minds of many teachers.

Moreover, there are numerous *a priori* reasons to regard mathematics as a slave rather than as a free, living, pulsating being, exhibiting the many exhilarating changes characteristic of youthful development. The reasonableness of the main postulates of mathematics has never been questioned. In most cases contrary hypotheses would appear perfectly absurd to those who have not been trained to mistrust their intuitions. The main function of mathematics has been, and probably always will be, to draw necessary conclusions from such postulates. Whether the postulates have been explicitly stated or not is a secondary matter. Hence mathematics has become a vast structure which is perfectly invulnerable except possibly at its foundation, and here the attack seems merely a matter of words. The most that has been done in an effectual manner is to erect structures on other sets of postulates. It should be emphasized that the main duty of the mathematician is to build upon given postulates. In these operations he will always be free from attack, since he can not arrive at any conclusion without proving that it is the only possible one.[2]

[1] Cf. Liebmann, *Jahresbericht der Deutschen Mathematiker-Vereinigung*, Vol. 14 (1905), p. 231.

[2] No attempt is here made to define the term mathematics. The views expressed are equally true whether mathematics is defined as a method, or whether the objects which it considers should enter into the definition. From

As mathematics enters into questions which are common to all society, from the most primitive to the most civilized, it is clear that some of its elements must always enter into the education of every one. Within these narrow limits there is little freedom of choice. In rising from this low view of mathematics to the one which recognizes its value in developing thought power and thought caution, one soon arrives in regions of the greatest freedom. From such a standpoint one can readily comprehend why so profound a thinker as Simon Newcomb should say, 'The mathematics of the twenty-first century may be very different from our own: perhaps the schoolboy will begin algebra with the theory of substitution-groups as he might now but for inherited habits.'[3]

During the last few decades Germany has wielded a predominating influence on the development of mathematics in this country. Hence it is natural that the tendencies of German mathematical development should be strongly felt in this country. Two of these tendencies are especially prominent: viz., the uniting of pure and applied mathematics, and the encyclopedic character of pure mathematics. Definite evidence of the former tendency is furnished by the rapid increase in the number of courses on the mathematics of insurance, mathmatics for students of physics and chemistry, and especially by the enactment of 1898 which made applied mathematics a distinct requirement of those who expected to become teachers of mathematics. While the American universities have been more conservative in these directions, yet there are many evidences that these tendencies are strongly reflected in the mathematical courses offered by our higher institutions.

Jacobi was perhaps the first eminent German mathematician who made special efforts to lead his students to the boundary between the known and unknown as rapidly as possible, and then to make them coworkers with him in investigating new problems. His methods were imitated very largely by others so that German mathematical instruction became, to an unusually large extent, instruction in research, or, at least, instruction in regions which had been very inadequately explored. These methods have been employed in other countries. In our own country their introduction was hastened by the teaching of Sylvester and Cayley, who employed similar methods while they were connected with Johns Hopkins University.

While the discovery of new truths gives an interest and charm

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the former standpoint, geometry, as commonly understood, is not mathematics. For a splendid exposition of the definitions of mathematics we refer to Bôcher, 'The Fundamental Conceptions and Methods of Mathematics,' *Bulletin of the American Mathematical Society*, Vol. 11 (1905), p. 115.

[3] Newcomb, *Bulletin of the American Mathematical Society*, Vol. 3 (1894), p. 107.

which can scarcely be attained in any other way, yet the early attack on research problems has not been free from undesirable results. If the mind is centered on one line of thought it is less apt to be in condition to receive deep impressions of other fields which may be equally important. Only the greatest minds have been able to attain to those broad and impressive views which comprehend the true correlation of the different lines of mathematical activity, in addition to making important contributions along any one line. In recent years there has been a tendency to encourage breadth of scholarship even at the expense of research in early years,—a tendency which Klein has aptly named encyclopedic.[4]

In American mathematical research activity was very limited until recent years. Within the last decade the mathematical productivity has more than doubled, both as to quality and as to quantity. This has been largely due to foreign training, as only very few of our larger institutions have a sufficient number of research men on their faculties to afford their students opportunities to enter upon fields of research which are best suited to their tastes and ability. Hence the encyclopedic tendency of German mathematics, and possibly also of that of France, should not affect us for a number of years.

The tendencies which have been mentioned relate principally to university instruction. During the last few years there has been an unprecedented activity along lines which relate principally to secondary schools. This movement is sometimes called the Perry movement, in view of the great activity of Professor John Perry, of the Royal College of Science, London. Perry's paper at the recent Glasgow meeting of the British Association for the Advancement of Science provoked a great deal of discussion, and was followed by the appointment of a committee with Professor Forsyth, of Cambridge, as chairman, 'to report upon improvements that might be effected in the teaching of mathematics, in the first instance in the teaching of elementary mathematics, and upon such means as they think likely to effect such improvements.'

In our own country the movement has been brought into prominence largely through the efforts of Professor Moore, who devoted a part of his presidential address before the American Mathematical Society to questions related to this movement. That the time was ripe for such a movement seems evidenced by the numerous organizations of teachers of mathematics with a view to the discussion of questions related to the improvements in teaching and in the selection of subject matter.[5]

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[4] Klein, *Jahresbericht der Deutschen Mathematiker-Vereinigung,* Vol. 13 (1904), p. 473.

[5] The following associations have been organized within a few years:

As might be expected these agitations have led to the most severe attacks on the present state of mathematical instruction. Professor Perry seems to have especial gifts along this line, as may be inferred from the following quotation:[6] "I would rather be utterly ignorant of all the wonderful literature and science of the last twenty-four centuries, even of the wonderful achievements of the last fifty years, than not to have the sense that our whole system of so-called education is as degrading to literature and philosophy as it is to English boys and men." This is the view of a man who, as chairman of the Board of Examiners of the Board of Education of London in engineering, applied mechanics and practical mathematics, has charge of about a hundred thousand apprentices in English night schools.

One of the main contentions of the agitators is that our mathematical instruction should be more concrete and inductive. This is frequently expressed by the term 'the laboratory method of teaching mathematics' and several of our leading universities have announced courses to be taught by this method. This gives evidence of a profound movement in methods of mathematical instruction, which will doubtless effect many reforms even if it can not be expected that the extreme views will find general adoption.

The teaching of elementary geometry has perhaps been most severely attacked. This attack has been supported, if not directed, by some of the very foremost mathematicians. Klein has recently said that the methods adopted in Euclid's geometry are unsuited for boys.[7] It has become the fashion of text-book writers to call especial attention to the rigor of their presentation. Fortunately these claims are generally unsubstantiated. There are few things that would give more definite proof of the perfect unsuitableness of an elementary text-book than the fact that every step in the presentation was rigorous. The history of mathematics shows that periods of discovery are followed rather than preceded by examination into the rigor of methods, and the same general principle holds in reference to the training of students.

In France C. Méray has perhaps done the most effective work towards reform in elementary instruction in geometry. At the last meeting of the French Association the section of mathematical sciences passed a resolution to request the association to address the minister

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Central Association of Science and Mathematics Teachers, Association of Teachers of Mathematics in the Middle States and Maryland, Association of Ohio Teachers of Mathematics and Science, Mathematical Section of the California Teachers' Association, Missouri Society of Teachers of Mathematics, Mathematical Association of Washington, Association of Mathematical Teachers in New England, Kansas Association of Mathematics Teachers.

[6] *Nature*, Vol. 65 (1902), p. 484.

[7] *Jahresbericht der Deutschen Mathematiker-Vereinigung*, Vol. 14 (1904), p. 41.

of public instruction with a view to encouraging the introduction of 'Méray's method' in the teaching of geometry. During last year this method was employed in at least thirty of the French schools, and very enthusiastic reports of improvement were received. The method is expounded in 'Nouveaux Eléments de Géometrie par Méray,' as well as in several of the French journals. One of its important features is the introduction of the notions of displacements and the group of displacements into elementry geometry.

While reform movements in mathematical instruction are not new, yet the present movement is without a parallel both with respect to its extent and with respect to its vigor. The question naturally arises whether the mental inclinations of civilized races are undergoing gradual changes so that concepts which at one time give pleasure and power to the youthful mind, at other times are beyond the capacity of the average mind, or whether we are becoming more sympathetic with the difficulties which have to be overcome in mental development and take greater precautions to make the steps natural. Whatever may be the cause, it seems probable that readjustment will be effected without departing very far from the older methods. The most likely changes in elementary instruction are those which Klein has been so actively advocating; viz., the early introduction and frequent use of the concept of a function and the teaching of the elements of analytic geometry and the differential and integral calculus at a much earlier period, before the student begins to specialize.

THE WEALTH OF THE COMMONWEALTH

By Dr. A. C. LANE

STATE GEOLOGIST OF MICHIGAN

IN these days of evolutionary theories and dominance of biology it has become fashionable to apply the analogies and language of biology in other fields—for the geographer to speak of mature rivers, and youthful drainage, and the sociologist and historian to speak of society and nations as organisms. So, without going so far as to assume that there are units of consciousness apart from brains, and that there is an American or Michigan consciousness standing in somewhat the same relation to your consciousness and my consciousness as ours may be supposed to stand in relation to the sensitiveness which may belong to each individual cell of the body, we may still accept the comparison of the nation or state to that of an organism so far as it may help to remember and connect real facts.

The youth of a people is in reality like that of a man, full of hope, extravagant, feeling boundless resources and inclined recklessly to squander them in attaining the objects of desire. If it is wisely guided, age may bring riches which are not merely in prospect, but in possession, which are the fruits of useful industry and the relics and mementoes of a noble ancestry. Unwisely guided, age may bring the exhaustion of the resources thought to be boundless, with nothing worth while to show for them; and as the individual man may be found bankrupt in purse and pride, so the nation or community may suddenly find its supposedly inexhaustible supplies exhausted, the fabulous fertility of its fields failing, its hills once clad in forests naked and seamed and gashed by gullies until they remind one of the beggar's clothes whose spendthrift habits have dragged him down to like depths of destitution.

Mill* says that 'looking on the world as not only the home of man, but as subservient in all its phenomena to the welfare of the human race, we may consider the development of any region to mean such treatment of its natural resources as will enable the land to continue to support an increasing number of inhabitants,' and ventures the suggestion that, "fortune hunting is inimical to development in its true sense. A fortune acquired through production or speculation can usually be made by only a few individuals and almost always entails the exhaustion of natural resources or the lowering of wages; a pros-

* Hugh R. Mill, 'New Lands,' p. 7.

perous livelihood, on the other hand, can often be secured to a multitude without permanent impoverishment of the land."

The former statement we may consider a very fair definition of development of a country. The latter is one of those general statements which are hard to disprove, being both vague and qualified. But it suggests that there may be such a thing as improper development. Much talk and writing seem based on the theory that development is always and only good—is a good in itself. This we may fairly question.

It is fit then to consider what is the path of wisdom, what is that true development of natural resources which scattereth and yet increaseth, and what is that development which may better be called devastation, whose scattering is not that of the seed corn which returns many fold, but that of the whirlwind and tornado. How best to conserve natural resources and secure adequate compensation for that consumption which is necessary are questions which interest scientists studying either the face of nature or the course of history, patriots desiring the welfare of their country, and parents desiring to pass on unimpaired the patrimony that has come down to them.

In the first place, note that the development of national resources does not in all cases imply consumption. It is true that one can not eat one's cake and have it too, but it is also true that one can use a house, see a picture, and gaze at a statue, and they be none the worse for it. Italy and Greece are vastly wealthier to-day than they would have been had the marbles of their statues remained in the quarries of Pentelicos, Paros or Carrara.

The marble still in the quarry has not the value that it has piled up in the Parthenon, and every Milton who dies mute, inglorious, but who might have sung immortal verse is a loss and waste, most of course to the higher and spiritual interests of the nation, but also to the commercial interests as well. I do not know how much cash loss of trade it would be to Stratford-on-Avon had Shakespeare lived and died there without knowing letters, but I do know that the American pilgrims to Europe are expected to leave 130,000,000 dollars, and a very large part of this comes from those who go to visit the footsteps of great men gone before us.

Thus a development of natural resources which means merely turning the material into more valuable, artistic shape, or surrounding it with inspiring associations—such a development is pure gain and no loss, so long at least as we do not bury living prophets under the tombs of their forerunners or shackle the present with reverence for the past. This accumulation of wealth may be either by the importation of art from abroad or by turning our own material into art forms. Particularly is this true of architecture and of furniture which are worthy to descend as heirlooms from father to son. Dollar chairs are no permanent gain to the assets of the state, Chippendale sofas are. The accumulation within the state of art treasures, that is to say of fine work in fitting material is, therefore, a means of increasing the wealth of the state. And schools and professional feeling which shall help the workman to become the artisan, to put individuality into his work and feel a pride in it, and money spent in the production and education of men who serve mankind and whose footsteps will be gazed upon with reverence by coming generations are directly helping the prosperity of the commonwealth. In so far then as work of artistic value is expended upon material which is retained in the state, there is a definite increase in the wealth of the state.

As a second class we have the resources of which there is a continuous and transitory supply, in contrast to those of which there is a stock, in the using of which we are drawing on an original supply or the accumulation of generations. The farmer's windmill in using wind power is using a resource of the former class, while the use of coal is drawing on a reserve.

Farm products so far as they are due to air, water, sunshine and hard work, the minting of golden sunshine into golden grain, are a development of resources continuously supplied, but there is also a little ash or mineral matter which, if not replaced by manure or fertilizer, is a draft upon the capital of the commonwealth.

Most important perhaps of these resources is water power, which is indeed largely used, but of which there are millions of horse power yet unused. Any permanent substantial dams which may help us to utilize this will be a permanent gain to the resources of the state.

Third, are the resources which are wasting away in the use. As we gaze on a piece of soft coal across the cleavage, we shall see dozens of alternating bright and dull bands in an inch. Each of these may represent an annual or semi-annual change of climate, and a ton of coal may represent thirty tons of wood. Thus in using coal we are dissipating in a few years the accumulations of generations heaped up millions of years ago.

Now of these reserve accumulations, and I can not emphasize the fact too strongly, there is never an inexhaustible supply. People a scant half century ago used to talk of the inexhaustible supplies of pine in the Saginaw. There is now hardly a stick standing. Men prate of inexhaustible mines. There are no inexhaustible mines. The bottom of perhaps the greatest mine in the world, the Calumet and Hecla, on its conglomerate is much too visible. The Spindletop bubble has already burst, and its wealth has practically vanished, wasting what should have been the industry of a generation in a scant decade. The towns that had natural gas no longer burn it in flambeaux that burn millions of cubic feet a day, but charge twenty cents a thousand for it. Of course sometimes the supplies are in a way practically inexhaustible.

The salt of Michigan, if the present rate of production of two billion pounds a year is not too greatly exceeded, might probably last some two million years. Yet the consumption will increase—we know not how much, and a much less time and amount would threaten the collapse of Detroit beneath Lake Erie.

They talked only a few decades ago of inexhaustible supplies of iron ore, and yet now a pretty well posted man says there is in sight but thirty or forty years' supply of ore—that is now merchantable, I presume he means. I would double that and say that, at the present rate of consumption of some 23,000,000 tons a year, there is probably enough for eighty years' consumption. Still that is not a very long time in the lifetime of a nation.

One thing must be noted in regard to this matter of exhaustion. It is rare that a resource supposed to be inexhaustible comes so sharply and entirely to an end as the pine of the Saginaw Valley (the *American Lumberman* says that pine is on the toboggan), or the countless herds of buffalo of the western plains, which were sharply wiped out between 1877 and 1887, so that the buffalo coats which the street car men wore when I was a sub-freshman were a luxury of the rich when I was graduated. Usually as the cost increases it tends to cut down the consumption until a certain balance is attained depending upon available substitutes, and so the price slowly rises and consumption keeps on decreasing. That is the way in which our anthracite coal fields, and the British coal and iron ores are now becoming exhausted; a large part of our anthracite now comes from fine stuff formerly thrown away. Moreover, in many cases there may be both an accumulated stock and a continuous supply. For instance, it is so to a certain extent with our forests. The magnificent growth the pioneers found here was an accumulated stock. But in many countries forests, like a farmer's wood lot here, are looked to for a continuous supply. We must soon be in that case. Originally the great white pine belt extended over 400,000 square miles and there may have been 700 billion feet of it at the beginning, say in 1851. By 1901 there was but 110 billion feet, which was going at the rate of seven billion feet a year.

So within ten years there will be no more white pine—it will be hemlock, jack pine, anything. As the annual consumption in the United States is some 25 billion cubic feet, and the total forest area of the United States is some 500 million acres, from which American lumbering practise will only get 420 board feet a year, it is obvious that even though we improve to the standard of the German practise of 660 board feet per annum, we must still either reforest large areas or find substitutes. It is difficult to see the national economy of rushing through our timber pellmell at a low price and then buying that of our neighbor, Canada, at a high price.

Besides stored up treasures of wood and coal, the loss by extermination of any native animal or plant is one which may indeed be small, but may easily be irreparable. The last survivor of those flocks of wild pigeon which once darkened the sun seems to have winged his solitary way to that bourne whence no traveler returns, which the fowler's eye may vainly strain to discern. The same thing is almost true of the wood-ducks. Logging operations have absolutely cleared many a stream of trout, and it might easily be that grayling, white-fish and sturgeon would become as unknown as the wolverine in the wolverine state.

I presume that in some exterminations like those of the rattlesnake and the wolf there is a distinct gain. But it is not well that we should let these exterminations of our animal neighbors go on in sheer heedlessness, but take some pains to preserve and propagate those most valuable. A great body of laws on game preservation and fish culture show that we realize something of this. Yet I venture to say that we still know far less than we might of what animals should be preserved and especially how best to do it, or which of our animal friends are being exterminated and how best to stop it. Many a well-meaning action fails in its object because based on imperfect knowledge. The laws for the preservation of lobsters are aiding their extermination.

First then as regards these exhaustible resources one should know what is happening. Again, the consumption should be as little wasteful as possible, getting the full benefit of all that is used.

Thirdly, the product should be so used that we may have something to show for the exhausted resources and, in particular, so far as possible, substitutes should be devised and developed.

Now as to the kind of knowledge we ought to have. Marl or boglime beds which have been used as the base for cement factories have been produced in the past few thousand years, but the lake algae and shells are still busy abstracting lime from the hard water. One thing which it would be interesting to know is how fast our marl beds are growing and how many acres of pond and bog and cubic yards of boglime a company would need to have so that when they got around they could begin over again. The state might well encourage such an investigation and also see how fast it could be accumulated by the fittest plants. In the same way with peat bogs. If peat comes to be a popular fuel, it will at first be mainly on accumulated peat that we shall draw; but it will also be worth while to know how fast a bog can be made to grow and whether its growth can be stimulated by changes in water level or by encouraging appropriate plants. It is a good reason that scientific research be endowed on just this ground, that when the present coal mines are exhausted one may know where most readily to find new, and when these in turn are but hollow voids some inventor shall have found a storage battery that will turn Ariel from a tricksy sprite to a mighty genius of work and make the windmill as much a source of power as the water-wheel. Thus as earlier sources of power, lumber waste and coal are exhausted, one may turn to oil or gas, or use water power to develop electric heat or grow fuel either as four-foot wood or as peat, whichever shall be proved by scientific experiment to be the most economical.

A Frenchman has recently suggested setting a coal mine on fire and pumping down just enough air to make water gas and then burning this gas as it comes to the surface. If this idea proves feasible it will add untold millions to the wealth of this state in seams which it will not now pay to burn. But in any case by the time our coal is gone we should be ready with our streams already dammed and copper cables covering the land to furnish more power from water than we now use from coal.

So again little by little the unfertilized farm will become less fertile, for in spite of all the care and skill of the Michigan farmer, the wheat product per acre of the lower four tiers of counties of Michigan does not bear the same ratio to that of the state that it once did. It is well worth while, therefore, to see that we are getting our money's worth in buying fertilizer to replace the fertility. It should be worth while to see that we do not squander valuable potash salts in making table salt, or burning lumber waste, etc. Again, as the forests depart, not only should we cherish what is left, but with the proceeds, before we are left naked, poor and desolate, we should plan and develop substitutes, tile and slate for shingle, cement, sand-brick and stone for building, stone, cement and steel bridges for wooden, and paving brick and macadam for cedar block and corduroy.

So too by the time the present iron ores are becoming exhausted scientific chemists should have found some economic method of smelting leaner ores or, better yet, of handling that vast bulk of iron ore, of which we now know, that is made refractory by only a few per cent. of titanium, and geologists may have found for us new ranges, or extensions of the old ones. Moreover the necessary consumption should be as little wasteful as possible. Legislation which is such that 'we skin through as fast as we can and then throw the land back on the state' is not wise legislation. There are, indeed, two parties in politics and in economics as to whether the state should hold for itself these natural resources. But if it be granted that the state should put these in the hands of individuals to exploit, it is certainly short sighted to then so legislate in the hope of getting back again 'unearned increments' by taxation that the individual is tempted or even forced to rush through the development, squandering a large proportion of the resources, in order to get the utmost possible returns to himself.

In the same way the policy of taxation which leads those with accumulated property to leave the state and transfer the money which they may have made from its resources to some other clime and their interests to other institutions will not correct any error which may be supposed to have been made in allowing them to accumulate that wealth in the first place.

It is often proposed to correct and control the excessive accumulation of wealth and the power or wealth by competition, but it must be remembered that competition is a most potent source of waste. The different iron ores are used together to produce a maximum amount of iron from a minimum amount of iron ore, because they are all owned by the same parties, regardless of the fact that some of the ores can be produced much more cheaply than others. But if the ore belonged to different parties and there were free and unrestricted competition the most cheaply produced ore would crowd the others for a time entirely from the market, and would cause a decay of the town supported by their development. I do not think that any one would consider this desirable, and certainly from the point of view of the geologist there would be a waste of resources.

It is lucky for Michigan that the iron ore of Lake Superior is held by a comparatively few strong corporations, the U. S. Steel Corporation having, say, a billion tons on the Mesabi range and many million tons on the older range. The Mesabi ore is a mere mass of varicolored dirt. I saw five forties last summer said to contain 200,000,000 tons of ore. All that has to be done is to run in trains of ore cars and load it on by steam shovels, after once the layer of clay till, etc., overhead is removed. The huge, yawning, red chasms thus left when weathered in the smoke of puffing locomotives and laboring steam shovels, present a volcanic and truly infernal picture. In time some of them will be 400 feet and over deep. The ore, too, is largely of the highest grade. What could any ordinary iron mine do in competition with such, especially those of Michigan, where the miners have all now disappeared underground?

Fortunately, however, it has been found that in the draft of the blast furnace in which these ores are reduced to iron, a good part of this light powdery ore is liable to be blown out if not held down by something more substantial. Moreover, a certain amount of some flux must be added to aid the flow of the iron, and the silica of some of our Michigan harder ores, poorer in iron, is admirably adapted to that end. And as the same interests own properties in both states they prefer, rather than to let their Michigan properties go to rack and ruin, to use a moderate amount of that ore and save wasting their Mesabi ore, even if thereby it is not produced quite as cheaply at the moment. They fix the price, and in the long run it will be doubtless better for the community and corporation. More iron will be made with less work, by mining the high grade and low grade ores together, than there would were the high grade ore first run and wasted and then the low grade ore developed. The same thing is true regarding coal. In an era of unrestricted competition only the choicest portions of the best seams would be put on the market provided, as is true, there is a possibility of producing more coal than can be consumed. So on Spindletop unrestricted competition crowded an area of less than 200 acres with derricks drilling holes as thick as they could be set and caused an expenditure of over $15,000,000, where a million should have been ample.

Customs, such as that of paying royalty only on the coal mined, may favor wastefulness. If the royalty were per acre foot, it would pay to mine more closely, as I have said in my report on coal. Thus it is for the state's interest that coal royalties should be per ton on coal in the ground, not per ton of coal hoisted. This is practicable and done in some coal fields. In the case of iron ore, too much property has changed hands on the basis of the ore in the ground, as shown by drilling.

In the same way in Indiana it has been found necessary to pass laws restricting the waste of gas or oil, because in so many cases it was cheaper for the individual to save the one and waste the other, regardless of the effect upon the resources of the state or his neighbor's wells. It would seem, therefore, that in relying upon competition as a cure for the ills of the body politic or in attempting taxation of the 'unearned increment' we should not fail to consider carefully the effect of these remedies upon the development or conservation of those natural resources of the state which, once squandered, no financial or political legerdemain can restore.

I know that the questions here raised are difficult ones and I know no panacea for all the wastes of the body politic. I might, indeed, suggest that it seems to me that municipal or state ownership is too often treated as synonymous with municipal and state operation and exploration. The Boston subway is a good illustration of public ownership and private operation, which apparently works better than would any other plan just now. I may perhaps remind you, too, that in Mexico all mining is under a system of state leases, and in Canada lumbering. State control under a system of wise leases, preventing waste, would seem to be wise, when complete state ownership was not. In the United States the policy has in general been for the state to divest itself of the title to its lands with the resources, even though they could be sold only for a song. and were mainly useful to be cut up into lots to be given away with 'free chickens.' Would not, in many cases, a lease for fifty years or longer have been exactly as well? It is a fair question, how far it is wise for a community to let its wealth go permanently out of its own hands, and in particular into the hands of nonresidents. Non-resident property holders have been a source of friction ever since the days of the nobleman who let out his vineyard to husbandmen and went into a far country. Harvard University years ago, instead of selling Boston real estate outright, had a policy of letting it on a 99-year lease. And of late every now and then a piece of property, like the Adams house, worth a couple of hundred thousand, reverts, and is a very welcome addition to their unrestricted funds.

Would it not have been, and even now be, a wise policy for the states and their land-owning institutions to have leased much of their lands for a term of years rather than deeded the property outright? Certainly a lot of land would have come back to them, and kept off that mælstrom of useless expense—the delinquent tax list. While this I would merely suggest, what I would urge is more careful and intelligent consideration of our waning natural resources, so that before they are gone we may develop substitute products and replacing industries, and that their proceeds may go in part into permanent improvements, stone roads replacing plank roads, stone or cement bridges wooden bridges, stone or cement dams wooden dams, and into other additions to the permanent wealth of the state.

It is hard to find any wealth that has been better spent for the permanent wealth of the community than that which has been spent on educational institutions. They produce intelligent citizens. They draw into the state an intelligent public which spend much money at the time. Many of them stay to help build up the state. Their buildings and equipment will be more and more Meccas and permanent objects of interest and attraction and resort. Their scientific researches will help to develop, to save and to replace our natural resources.

I can picture in my mind two fortunes, and they will be but composite photographs drawn from life. The one is built upon a reckless cutting out of the choicest of the lumber, none but the best taken, the brush left around and fired, either purposely or fraudulently, to conceal theft. In the path of the first fires is left either a tangled mass of worthless trash, overgrown with bushes and fireweed, ready fuel for the series of conflagrations that sweep through from time to time, or a sandy plain covered with sweet fern and goldenrod, used by speculators to defraud the settlers, who from time to time try to make a livelihood from it. There are here three wastes, the half-gathered crop of timber later burned, the land left in a useless condition, and labor wasted in trying to make it useful. The logs thus gathered are driven to the mill by a crew of loose livers whose hard-earned wages are largely scattered to the dive and brothel in a few weeks. The saw mills devour them and circular saws rip a wide swath of sawdust waste at each cut; piles of slabs, sawdust and waste of every description are transported in a continuous stream to an ever-burning fire whose pillar of cloud by day and fire by night betokens not the presence of Jehovah, but the demon of destruction. The timber itself is shipped away, and the money thus acquired by one who keeps on making money because he does not know what else to do is squandered by his heirs, who by themselves or by those whom they purchase as husbands scatter it to scandalize two continents.

The forest, the accumulation of generations, and of ages of sunshine, rain and dew, is gone, and there is less than nothing to show for it. This is criminal waste.

Now let us paint a brighter picture. Into the forest go a lot of pioneers, such as Ralph Connor loves to picture, bent on caring for themselves and their children. The instructions are to cut every green top, and every thing is gathered up, even old half burned logs. Whatever is not otherwise used is used for fuel in making salt, but all that can be used down to stuff that will only make lath or matches or toothpicks is saved, and pains are taken to make even the narrow bandsaw cuts as narrow as may be. The land is left ready, if it is good enough, for one of those same sturdy pioneers to take hold of and make a farm that will be the stay of his old age and the homestead of his children. That best fitted to remain forest returns once more to the state to be reforested.

The lumber goes where it is most needed, but part of it into buildings within the state, of permanent artistic value. The fortune thus acquired is expended perhaps in part in reforesting those parts of the tract that are better suited for forest growth permanently than for anything else, and in their fire protection, but those lands hardly worth paying taxes on are deeded to some state institution, to which after some years they will be of great value, while in the meantime they are kept off delinquent tax rolls. Another part of this fortune is employed in permanent improvements, roads and railroads, and in buildings which are a permanent addition to the beauty of the state as well as a memorial of the man who reared them. Another part goes in starting industries and providing education which will open fields of useful and valuable employment and keep alive the town where the fortune is made when lumbering ceases to be the all sustaining occupation. A part may be employed in exploring for coal, developing peat or water power, drilling for oil, mineral water or other resources to replace those that are vanishing.

The forest is then not wholly gone, and in the place of the part taken are fertile farms, with happy homes, noble buildings, intelligent people and varied industries, and the state is wealthier than ever.

The one picture is as true as the other, though they are put together like one of Thompson Seton's stories. That the brighter picture should be the one becoming more true. each man of intelligence enough to recognize the situation, each citizen of the kingdom of science, as well as the republic, should strive.

THE HONOR SYSTEM IN AMERICAN COLLEGES

By Professor W. LE CONTE STEVENS
WASHINGTON AND LEE UNIVERSITY

A CRITIC who was fond of unusual statements once declared that ignorance and unconsciousness are the best tests of good health. The man whose digestive powers are unimpaired has no conclusive evidence of his possession of a stomach. Hunger may be referred to as an aching void, but the discomfort is not localized until the digestive machinery gets out of order and pain tells the victim that in some way he has abused an internal friend whose unknown presence has been a source of quiet serenity.

In American educational circles the honor system in colleges has been a subject of discussion only since the close of the civil war. Prior to that time, like the unobtrusive stomach, it had long performed its function peacefully in some parts of our land, while the general public was ignorant of its existence. Of late years there has been enough internal disturbance to suggest the presence of a collegiate organ that demands recognition.

It is not possible to say just when or where the honor system had its birth. It had indeed no birth, but was merely a manifestation of social conditions at the south. During recent years the annual catalogues of the University of Virginia have contained the statement that in June, 1842, after the system of surveillance in written examinations had been found ineffectual, Judge Henry St. George Tucker, professor of law, induced the faculty to adopt the following resolution:

> That in all future written examinations for distinction and other honors of the university each candidate shall attach to the written answers presented by him on such examination a certificate in the following words: I, A. B., do hereby certify on honor that I have derived no assistance during the time of this examination from any source whatever, whether oral, written, or in print, in giving the above answers.

The editor of the catalogue adds 'this was the beginning of the honor system.' Such a conclusion is warrantable if understood to mean that this was probably the first formal adoption of a college code of examination ethics that had been previously in existence without formal legislation. The South Carolina College has within the present year celebrated the centennial anniversary of its organization, which occurred twenty years before the incorporation of the University of Virginia. In a sermon delivered on January 8, 1905, the chaplain of the college, Dr. Flinn, declares that 'in the very beginning of the history of the college the honor system of student control was established.' He quotes a by-law, formulated by the trustees of the college, certainly within a few years after its organization and published from year to year, in which the essential principle of the honor system is set forth in these words:

> The sense of decency, propriety and right, which every honorable young man carries in his own bosom, shall be taken as a sufficient means of knowing these things, and he who pleads ignorance in such matters is unfit to be a member of the college.

No one of the present generation can properly make any definite statement as to the universality of the honor system in our institutions of learning a century ago, or even a half century ago, but in most of our older southern colleges tradition seems to indicate that it has long been in force.

It is easy to understand why southern colleges should have been the natural home of the honor system. The distinguishing characteristics of southern civilization a few generations ago made it to a large extent spontaneous. Education was not deemed a necessity for all, but rather a privilege belonging to those who could claim, either actually or prospectively, the title of gentleman. A young man went to college not with a view to preparing for a special vocation in life, but because a liberal education was generally regarded as the indispensable badge of the gentleman. Elective courses were unknown. Latin, Greek, mathematics and moral philosophy were studied by all and mastered by few. To be recognized as a scholar was a high honor, and those who achieved it felt a pride in their ability to quote from Seneca or Homer in the original. The son of a gentleman was taught to despise deceit. Cheating was naturally to be expected among traders and day laborers, but these could not be expected to study Seneca or Homer, to seek the scanty knowledge of astronomy and botany that was offered as science, chiefly with a view to its bearing on natural theology, or to appreciate and analyze the evidences of christianity on which every college-bred gentleman was required to stand examination before receiving the degree of bachelor of arts.

We have no special ground for thinking that human nature has ever been very different from that of to-day, and the college classes from which our grandfathers were graduated must not be invested with any halo of sanctity. Neither virtue nor vice belongs more to one generation than another, whatever may be the color of the telescope glasses through which we look back at our ancestors. There is no reason to suppose that manners and morals were any better a century ago than to-day. The advance in civilization suggests the presumption of improvement, but morality, as well as knowledge, is relative; and offenses change in importance with the lapse of years. Whatever may be the gains that we have made otherwise, the obligation to avoid cheating in the college examination room was certainly more insisted upon by southern students prior to the civil war than it is to-day in the country at large. Custom and tradition had established a standard that every son of a gentleman felt it his privilege and duty to maintain. To violate this unwritten law was perilous for the young man whose home training had been defective. The temptation to cheat might be strong, but to incur the contempt of his fellow students was a risk that could not be lightly undertaken.

The firm establishment of such a code of college honor at the south was undoubtedly an outcome and manifestation of the extreme conservatism characteristic of that section during the period when communication with other parts of the world was very limited. It antedates the railroad and telegraph. Travel was restricted, and local customs were correspondingly fixed. Similar restriction existed, perhaps to a less extent, at the north; but at the south the institution of slavery had established class distinctions in society which were more sharply defined than was possible where the population was almost confined to a single race. The southern college was completely dominated by a single social class. The upheaval and confusion, the impoverishment and chaos due to political destruction and reconstruction, were not sufficient to extinguish at once the college traditions established by an aristocracy that retained its pride after its wealth had been annihilated. The honor system was cherished as a heritage to be proud of, one that was inseparably linked with the traditions of the lost cause.

Forty years have not been enough to efface the influence of these college traditions at the south. At the north they had never been established. This statement does not imply that the ethical code customarily in force among northern students was inferior to that at the south. It means that certain actions were forbidden by student opinion in the one section and deemed permissible by student opinion in the other, such opinion being in each case determined chiefly by local precedent. Political fealty and church affiliation are well known to be determined more frequently by prescription rather than by argument. It would be remarkable if student opinion were more judicial. The differences of opinion between a democrat by inheritance and a republican by inheritance are certainly no greater than between southern and northern students in their traditional views about the honor system. Neither side has a monopoly of virtue.

The present writer was reared amid influences where the honor system was dominant, receiving his baccalaureate degree in South Carolina. During college days on one occasion he took part in a mass meeting of students held for the investigation of a supposed breach of the honor system. The questions to be used in a written examination had been printed, and an unpopular student was accused of securing a copy from the printer on the night before examination. Conviction would have implied his expulsion by demand of the student body. The ground of complaint was not so much that the use of the questions would be unjust to fellow students as that the action alleged was characteristic of a sneak unfit to associate with gentlemen, and involved the culprit's signature to a false statement that his answers were written without aid. The accusation was based on circumstantial evidence alone and could not be sustained. The trial was necessary in the interest of the defendant, whose accusers were fellow students. So long as there exists such a jealous demand on the part of students that cheating shall not be tolerated in any form, direct or indirect, college authorities are abundantly safe in allowing them self-government.

But all cases are not so simple as the one just cited, nor is popular sentiment usually so pronounced as to secure the prosecution of offenders. Indeed the honor system is no longer a characteristic of any one section of the country. In the same institution of learning it may be trusted during one year and found wanting during another. College tradition has been perceptibly weakened during forty years. Ideals of education have been revolutionized, and it would be extraordinary if ideals of college honor should not be subject to gradual modification. The assumptions that once served as the foundation of the honor system can no longer be accepted without reservation, and the administration of such a system must be modified to suit changed conditions. It may be instructive to inquire briefly into these changes.

The southern college is no longer under the control of the social class that was in power when the honor system became established as a fact without being known as a system. With the establishment of public education at the south the classical academies have been dying out, one by one, and their places taken by the public high schools of the cities. The spirit of inherited aristocracy has been gradually disappearing, and with it are vanishing the home ideals that were formerly carried to the college. Population has grown, and the diffusion of elementary education, though still far from complete, is much better than it was a generation ago. Young men no longer come to college to receive the badge of respectability. They come to secure as directly as possible what they hope to utilize in the approaching competition with the world for a living. The testimonial of scholastic success is a baccalaureate or professional degree, the value of which depends upon the reputation of the college. Culture for the sake of culture, training for the avowed purpose of mental gymnastics, the pursuit of science for the love of knowledge and the desire to add to the sum of human ideas, have their advocates still, especially in the universities; but to the great majority of students such motives are foreign. The greatest stimulus to effort is success, and the love of conquest in competition will continue indefinitely to incite students to activity in apparent disregard of utilitarian ends; but with all due allowance for this well-known fact in human nature, popular ideals have changed to such an extent that the maintenance of the honor system must be based on a foundation different from that which maintained it during its early development.

A college degree involves an expenditure of much labor, and often of money that the student can ill afford. In preparing for his examinations he is at times compelled to grapple with topics that are unattractive, subjects that would be sedulously disregarded if they were not prescribed as requisites for the degree sought. If credit can be secured for success without full payment in labor, if deception can be practised for the avoidance of irksome tasks, is such procedure different from current practise in the world of business? Can the student be expected to rise in the college class-room above the ordinary standards of honor in society, in the street or on the athletic field? If the most conspicuous leaders in politics, the organizers of great business corporations, the presidents of railroads and insurance companies, grow rich and prosperous by taking advantage of their opportunities to appropriate unearned dividends, to concentrate on the favored few what belongs to the unprotected multitude, is it remarkable that a student under temptation should profit by such lessons and make the best of an opportunity to win an unearned degree, or secure unearned credit for an examination by misrepresentation? The honor system in college is merely an application of the standards of Washington and Jefferson and Lee in political life. If such standards are too antiquated and simple for twentieth-century politics and finance, nothing can maintain them in the twentieth-century college.

But the honor system is not yet extinguished, hopeless as may be the outlook for it in some quarters. Its existence in any institution of learning is possible only where the demand comes from the majority of the students rather than from the faculty. If such a demand is based on local tradition alone it is doomed to inevitable extinction. No tradition can survive in opposition to the consensus of contemporary thought and feeling. But it has its reason for existence, quite aside from tradition, in the sense of justice and fair play. The majority of young men under normal conditions are disposed to uphold what they conceive to be just. In general society penal laws are necessary to restrain criminals, and the criminal is the exception. The college criminal who cheats in the performance of college duties is found in every college, but he too is exceptional. If he and his friends are so active as to necessitate penal laws that imply hardship to the student body as a whole, the majority have a right to demand the expulsion of the offender.

It was under such conditions as these that the honor system was adopted at Princeton about a dozen years ago. It was introduced likewise at Cornell University, at Amherst, Williams and other northern colleges. At Princeton it is reported to be still giving satisfaction, although there have been occasional spasms of apparent weakness. In the other institutions named it seems never to have become very deeply rooted. Its maintenance, as well as its introduction, required organization among the students and tact on the part of those whose duty it was to teach and examine. There seems to be a growing feeling that the honor system, even if exotic, ought to be encouraged if students can be induced to adopt it; that self-government is the best government if it is only real government. But where no supporting tradition already exists on such a subject it is as hard to make reliable calculations on the stability of student opinion as on the magnitude of political majorities.

For the introduction of the honor system into any institution of learning, or for its subsequent efficiency, the first essential is the organization of a college court, composed of leading representatives from the most important classes or departments. The efficiency of such a court depends upon the earnestness and watchfulness of a small minority of the student body who are public spirited enough to endure temporary inconvenience and to risk their personal popularity by reporting those who offend against the laws adopted by the student body. If there are never any indictments there can be no need for a court. Since the college world is not wholly made up of angels, it is absolutely certain that offenses will be committed. If nobody is willing to act as prosecutor or complainant the law becomes a dead letter, and the court dies a natural death. But such a court should be organized in every college and its vitality should be tested by actual practise. To its jurisdiction should be committed all cases of crookedness in class or examination or in anything else that affects the welfare of the student body. If a young man shows to his fellow-students that he is dishonest outside of the class-room, it is not necessary that the enforcement of the honor system should be limited to matters connected with written examinations. The voice of the student body should be heard even if it be not always judicial. The student court should indeed not be a court of last resort. Its rulings should be subject to examination by an appellate court consisting of the president and a committee of the faculty of the institution. The right of appeal to this supreme court should never be yielded, but such appeal should not be demanded unless strong reasons for it can be established.

Even if a good student court has been organized, the maintenance of the honor system may be and often is nullified by the unwillingness of students to inform against the violators of law. This indeed is the greatest difficulty to be overcome in practise. A student whose mental ability is limited, but who is conspicuous in athletics and personally popular, yields to temptation in the examination room, or otherwise resorts to fraud in order to win scholastic credit. He is shielded by the members of his fraternity, and their influence is such as to prevent his indictment before the college court even if his offense is repeated several times. At last he is caught by some professor through internal evidence in an examination paper. He denies his guilt and his friends join him in the effort to make conviction impossible. The evidence is overwhelming and he must go. The loss of a leader on the athletic field is bewailed as a calamity to the athletic interests of the college, and a stay is secured on some technicality by which the dishonest athlete is retained until the close of the football or baseball season. He then goes, not in disgrace, but with every manifestation of regret on the part of admiring friends. Resentment is felt and openly expressed against the tactless professor whose abnormal conscience has made him expose the athlete's moral weakness. Of what importance is scholastic accuracy in comparison with victory in athletics? Why can not professors exercise more common sense and overlook the shortcomings of those whose athletic success advertises the college among young men more in one day than the professors can do in a year? Is college spirit to be disregarded in deference to out-of-date aphorisms about telling the truth? Has a student no right of mental reservation in signing an examination pledge when he has been unselfishly giving to athletics most of the time needed to prepare for examination? It is all well enough to insist upon the honor system when competing for honors, but why not give a chance to the fellow who wants merely to stay in college, to shine in young society and to help support all college enterprises?

The dominance of athletics as a factor in college life constitutes to-day one of the most serious obstacles to the maintenance of the honor system in colleges. The difficulty of maintaining clean athletics is notorious. So strenuous is the demand for victory that honor must go if it is accompanied with the danger of defeat. The jesuitic claim that the end justifies the means is continually made under various forms of disguise, and its reacting influence on the ethics of the class-room is inevitable. In an institution where the honor system is in force the football team is made up of young men whose examination pledges are respected. But in an intercollegiate match this team is called upon to meet competitors from a distance, and the code of ethics is changed to provide for the trickery and disguised professionalism in which the strangers are known to indulge. The honor system is reserved for application at home, but elsewhere the athletic organism must adapt itself to its environment. Cheating becomes allowable because it has been found impossible to exclude it from athletic contests. If the devil must be fought it is soon agreed that he shall be fought with fire. The honor system has no place in intercollegiate athletics. Even some of the most ardent advocates of athletics admit despairingly that honesty in athletics can no longer be expected. Trickery and ruffianism are admitted to be necessary for victory. If such is the practical athletic code, familiarity with its working must inevitably affect the athlete's ideals in all cases where his interests are to be affected. If dishonesty is right in the collective struggle for victory it is but a short step to the conclusion that it is equally right in the individual struggle for a pass in examination. The claim is openly made in some colleges that the student is perfectly justified in cheating to win a pass mark, but should not cheat in a contest for honors.

The influence of intercollegiate athletics, and other influences that are obtrusive in politics and business, have already had a noticeable effect on the honor system among southern students. Taking the south as it exists to-day, the hold of the honor system in a few institutions is yet strong; in others precarious; and in still others quite non-existent. It would be easy, but not appropriate, to fortify this statement by mentioning concrete cases and giving names. Where the college is old, and especially if it is situated in a village or small city, the maintenance of tradition and of well-defined unwritten laws relating to student life is comparatively easy. If it is situated in a large city the relative importance of the college in comparison with other interests in the community is dwarfed, and the commercial spirit of the age is quite sure to become dominant. No well-defined code of college ethics can become established where the majority of the students meet only in class-room or laboratory, and where they are merged during the hours of study and recreation amid tens of thousands of people who never think of the college as a living organism with a recognized collective character. Young men who become enrolled in city colleges must be expected to exemplify the business ethics of the city. Among them will be found many individuals of high moral tone, as worthy of trust in the examination room as in the parlor. Fraternities and social cliques may be formed, but usually no general code of college ethics can become crystallized under the conditions of city life.

The conditions that are favorable and those that are detrimental to the maintenance of the honor system among students may be briefly summarized as follows:

1. The difficulty is least in small towns and greatest in large cities, as just set forth.

2. The difficulty is least with the most advanced students and greatest with freshmen. The advanced student has a well-defined purpose in view and appreciates the fact that his own interests are bound up with the actual mastery of the subject in which he is working. The young student is just from a preparatory school where probably he has

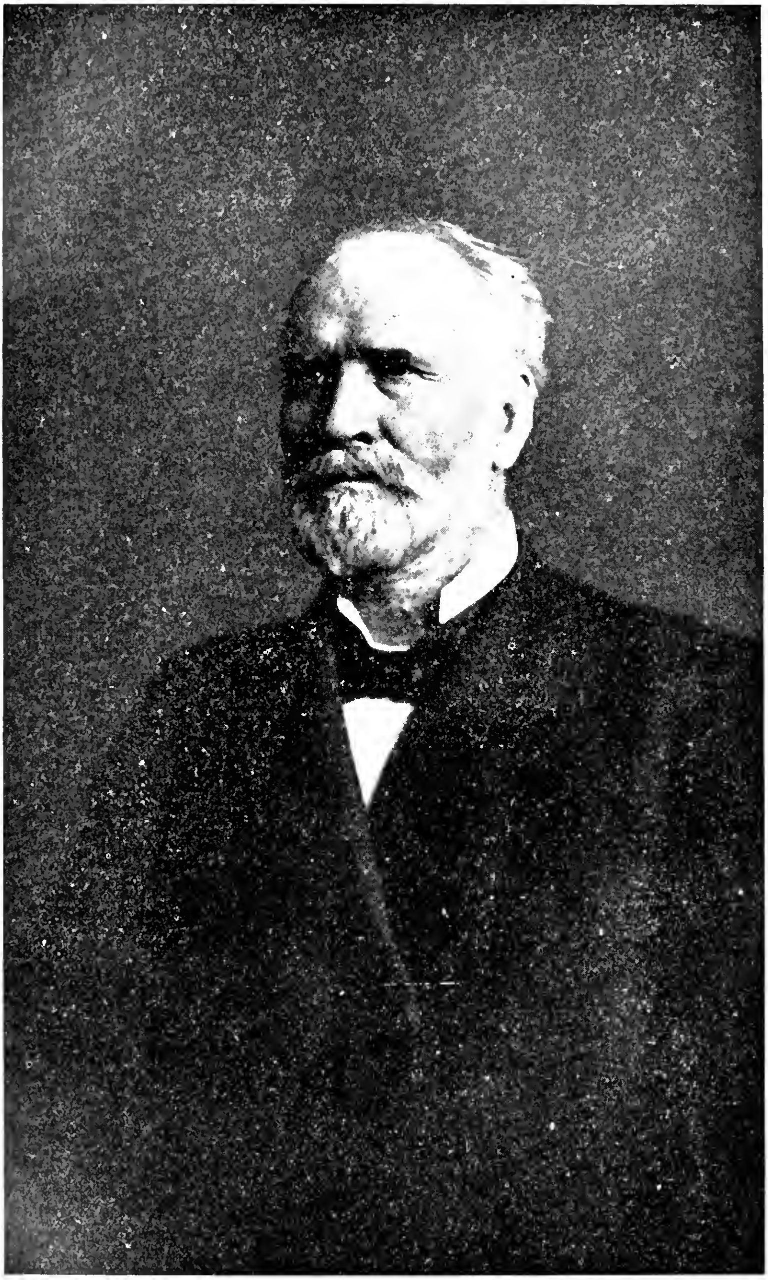
been thoroughly imbued with the idea that the chief object of his teachers is to impose tasks and limit his personal liberty. He feels a certain degree of exultation in 'getting ahead' of those whose duty it is to be vigilant, and he carries this spirit to the college. The temptation to cheat continues as long as fetters exist, whether actually or in his imagination.

3. The difficulty is least where there is the greatest freedom in the election of courses of study, and greatest where a fixed curriculum is maintained with a high standard for graduation. The existence of a curriculum implies rigidity. The student must endure much arduous labor because it is prescribed. He may be informed that it will do him much good in due time, but he is skeptical, and cheating is the most natural resource.

4. The difficulty is observed to be greater in technical and professional schools than in those where much of the work is avowedly for the sake of culture. In the technical school the cost to the student is high. He wishes to begin applying his acquisitions to the work of self-support as soon as possible. To fail in an examination may mean the spending of many hundreds of dollars extra, and the loss of a year of valuable time from remunerative employment. He regards the entire subject from a commercial standpoint and treats it as such.

The most conspicuous tendency in America of late years has been toward the substitution of urban activity for rural quiet. Urban standards are increasingly established in all the more prosperous institutions of learning outside of the cities. The gradual extinction of the honor system in colleges, as we understand this term to-day, seems, therefore, inevitable. Such a conclusion, though unwelcome, is not wholly pessimistic. The honor system where it now exists should be carefully guarded and everything possible should be done to encourage self-government in colleges, to develop the feeling of responsibility among the students for the integrity of the degrees conferred by the institution with which they are identified. The reputation of the college suffers irreparable injury if the public has reason to believe that its degrees are won by fraud. But in general society the honor system has its substitute in the unwritten code maintained by people of refinement and social culture. When interests clash or crime is committed recourse is had to the law of the land, and well known rules of legal procedure are applied. By the general public a man of honor is recognized as such after his habits of speech and action have been manifested and his character has become thus established. Whatever may be the differences of standard professed, college ethics will be conformed to the ethics of general society. Every student should be at least provisionally assumed to be a man of honor; and he should be treated as such so long as his conduct warrants the assumption. In the great majority of cases his word can be accepted, just as this is done in polite society. But to make the rule universal, because the honor system is in force in a college, secures the most convenient cloak possible for the perpetration of fraud by the unprincipled student who knows that his denial of guilt will be promptly accepted. If a lie is convenient why not utilize it when no obstacle to self-interest is interposed by conscience? The acceptance of his word should be subject to modification by other kinds of evidence just as it is in every court of justice. No rule can be laid down regarding the discrimination between students who are reliable and those who are unfit to be trusted. The trickster should be distrusted until he is eliminated, but tact and discretion are needed in dealing with him. He is found in every community, and he should not receive the protection implied in treating all students as men of honor.

Let the honor system be maintained and applied to all who prove themselves fit to receive its benefits. College interests will sometimes clash, and college crimes will occasionally be committed, proving that some students are not gentlemen. If changes in the present administration of the honor system become developed they should be chiefly in regard to the rules of legal procedure. Let the college court be maintained and trusted so long as students manifest the disposition to make it really efficient. An honor system conducted in accordance with the rules of legal evidence will not secure perfection; but college ethics a century hence will be at least as good as to-day, and better adapted to changed conditions than if manufactured according to the prescription of the wisest of contemporary prophets.



The Hon. James Wilson, Secretary of Agriculture.

THE PROGRESS OF SCIENCE.

THE WORK OF THE DEPARTMENT OF AGRICULTURE UNDER SECRETARY WILSON.

THE annual report of the secretary of agriculture is a record of scientific investigation and attainments by the national Department of Agriculture for the past eight years. The broad relations of the department's work give the report a wide general interest, and it illustrates anew the many practical benefits which may accrue to every-day affairs from intelligent and well-directed research and experimentation.

Secretary Wilson assumed charge of the department in the spring of 1897, and has been at its head since that time. This unusual period of service has been marked by rapid developments in work and organization, and by the elevation of the department as a scientific institution and in public estimation. The appropriations during this period have more than doubled, as has also the personnel of the department, and the scientific staff has increased from 925 in 1897 to 2,326 at present. Viewing the department's work in retrospect, it is somewhat surprising to note how many of the features which have brought it into prominence date from the present administration. The work in forestry, for example, which has assumed a position of such widespread importance, has been almost entirely developed during the past eight years. With the offer of practical assistance to forest owners in the management of their tracts, 'the field of action shifted from the desk to the woods'; and this was the beginning of a comprehensive movement, resulting in the formation of an intelligent public opinion and sound national sentiment which are rapidly placing the handling of forests and of the forest reserves upon a more enlightened and conservative basis.

The agricultural experiment stations in Alaska, Hawaii and Porto Rico have all been established and placed upon an efficient working basis under the present administration, and the influence and assistance of the department have thus spread to these remote possessions. The investigations in problems relating to irrigation from an agricultural standpoint, as distinguished from the strictly engineering features, have been inaugurated and organized upon a comprehensive scale. This work has proved so eminently practical and so important to irrigated agriculture that it has grown rapidly in extent and in scope, its appropriation having increased nearly tenfold. Out of it have sprung the work in land drainage and the still newer investigations upon agricultural machinery, so that operations covering practically the whole field of rural engineering have been inaugurated as an entirely new feature.

The breeding and selection of plants and varieties better adapted to special conditions or uses have been developed into a conspicuous feature, as has also the introduction of plants from foreign countries. Agricultural exploration for this purpose was instituted by the present secretary in 1898, with a small portion of the congressional seed fund which he was given authority to expend for that purpose. This has resulted in a vast number of introductions, such, for example, as the date palm, Turkestan alfalfa, Japanese rice, durum or macaroni wheats, and numerous other cereals. Durum wheat was first introduced in 1899, and has proved of such advantage in semi-arid lands that about twenty million bushels were raised this year. The propaganda for sugar-beet culture was inaugurated soon after the present secretary came to the department, and the widespread tests of its adaptation to different parts of the country have shown the regions especially adapted to the crop and been followed by a nearly tenfold increase in beet-sugar production.

The Weather Bureau has greatly extended the range of its observations and its investigation in the domain of meteorological science, with the result of increasing efficiency and a wider application of its work. It is now said to be the most highly developed weather service in the world. The soil survey has been entirely developed under the present administration, and constitutes the first systematic attempt to make a comprehensive soil survey of the United States. In economic entomology there have been very important developments, and the scope of the work has been more than doubled, not to mention the extensive scale on which the Bureau of Entomology has worked in the campaign against the cotton boll weevil.

The Bureau of Animal Industry, in addition to stamping out an outbreak of the foot-and-mouth disease in New England, has attained very important results in the study of animal diseases and their control, and the meat inspection in its charge has very materially increased. The inspection work has also been extended under the Bureau of Chemistry to other food products intended for export and import, and a system of food standards has been worked out as a basis for guidance in federal, state and municipal food inspection.

These are only a few of the many lines enumerated in which investigation has been inaugurated or important progress made. The showing is a gratifying one, and affirms how definite has been the aim in expanding and developing the department to meet the manifold needs of our unusually diverse agriculture. In a word, its twofold object has been 'to add to the sum of intelligence of the man, and to increase the productive capacity of the acre.' In this it has been strongly supported by the agricultural experiment stations of the country, to which the secretary makes appreciative acknowledgment. "Not only have the stations been a vital factor in making the department's work more effective," he says, "but they have by their own investigations lifted American agriculture to a higher plane." These two great agencies working together have laid the foundation of a science of agriculture as a basis for teaching and practise, and have won the confidence and appreciation not only of the farmers but of the general public.

THE NEW ORLEANS MEETING OF THE AMERICAN ASSOCIATION.

The meeting of the association at New Orleans during the Christmas holidays was thoroughly enjoyed by those members who were able to be present, and was of service in increasing in the south the influence of the association and interest in scientific work. The attendance was small, only 233 members being registered, but this was foreseen. The trip from the main centers of scientific activity was long for the Christmas holidays, and in most of the sciences meetings were being held simultaneously in more accessible places. The total number of scientific workers in the south is lamentably small. It appears from a computation recently made of the residence of the thousand leading men of science of the United States that only four of them live in the states of Georgia, Alabama, Louisiana and Mississippi; whereas there are 144 in Massachusetts, 43 in Connecticut, 35 in New Jersey and 47 in Maryland. The south has enjoyed a noteworthy development in its material resources in the past decade, and there is every reason to assume that its universities and other institutions concerned with the advancement of sci-

W. S. Eichelberger, Professor of Mathematics, U. S. Naval Observatory, Chairman of the Section of Mathematics and Astronomy.

ence will in the course of the next decade witness a parallel progress. And to this end the visit of the association to New Orleans will surely contribute.

New Orleans has the characteristics which with some exaggeration we attribute to the south. Its people are pleasure-loving and hospitable; the streets and restaurants are crowded; there were during the week of the meeting two race tracks in operation and two companies giving grand opera. As might have been expected the welcome to the association was cordial, spontaneous and unorganized. The meeting was truly appreciated, for in no place is science more highly esteemed than in New Orleans at the present time. As the Hon. C. F. Buck worded it in his address of welcome: "Our people are in a mood of worship in this regard. Through all the generations of the past has hung a dread, impenetrable shadow over our destiny. A mysterious disease which baffled human skill in its treatment and defied inquiry into its coming and going threatened all our hopes and expectations indefinitely. Science has lifted the shadow and unlocked the mystery. We look the future in the face with a new hope and an unshaken confidence. Your coming to us, so far away from the usual centers, just at this time, appeals to us like a voice of succor and a helping hand in a wilderness."

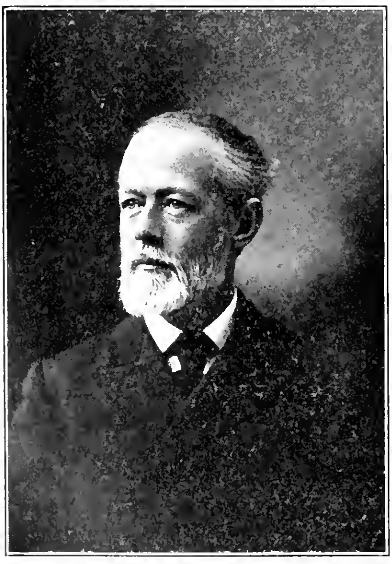
W. T. Sedgwick, Professor of Biology, Massachusetts Institute of Technology, Chairman of the Section of Physiology and Experimental Medicine.

F. W. McNair, President of the Michigan College of Mines, Chairman of the Section of Mechanical Science and Engineering.

An interesting series of addresses was given by the retiring president, Professor W. G. Farlow, of Harvard

Henry Crew, Professor of Physics, Northwestern University, Chairman of the Section of Physics.

University, and by the vice-presidents of the sections—Professor Alexander Ziwet, of the University of Michigan; Professor Leonhard Kinnicutt, of the



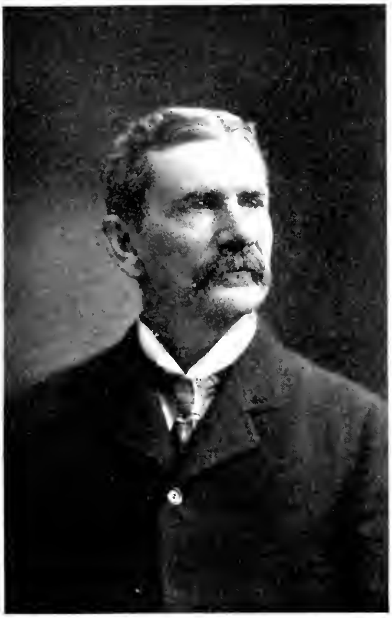
Wm. North Rice, Professor of Geology, Wesleyan University, Chairman of the Section of Geology and Geography.

Worcester Polytechnic Institute; Professor E. A. Smith, of the University of Alabama; Dr. C. Hart Merriam, of the U. S. Biological Survey; Professor W. F. Magie, of Princeton University; Professor B. L. Robinson, of Harvard University, and Dr. Martin A. Knapp, of the Interstate Commerce Bureau Commission, and Professor David S. Jacobus, of Stevens Institute. These

Henry B. Ward, Professor of Geology, University of Nebraska, Chairman of the Section of Zoology.

addresses are in course of publication in *Science*. Dr. F. P. Venable, president of the University of South Carolina, gave a presidential address before the American Chemical Society, and Mr. Elwood Mead, of the U. S. Department of Agriculture, gave a lecture complimentary to the citizens of New Orleans.

The programs of the sections, presided over by the vice-presidents, some of whose portraits we are able to give, were of unequal scientific value. The section of anthropology had no meetings, and in the cases of geology and zoology the programs were small. This is explained by the fact that the anthropologists were meeting at Ithaca, the geologists at Ottawa and the zoologists at Ann Arbor. On the other hand, the chemists had their usual strong meeting with a program of eighty-two titles.



C. F. MABERY, Professor of Chemistry, Case School of Applied Science, Chairman of the Section of Chemistry.

The section of social and economic science also presented a full and good list of papers. Perhaps the most appropriate and interesting program was that of the section of physiology and experimental medicine, which arranged a discussion of yellow-fever and other insect-borne diseases, taken part in by some of those who have contributed in an important measure to our knowledge of these diseases, including Dr. James Carroll, who made the original experiments proving that yellow fever is transmitted by the mosquito and not by direct contagion.

The association decided to hold a special meeting at Ithaca at the end of June, and to hold its regular annual meeting at New York next winter. The decision to hold two meetings, reached after careful consideration at Philadelphia and at New Orleans, is an important movement, showing the growth of science in the country and the increase in the influence of the association which has now 4,300 members. The vice-presidents elected are:

Section A — Dr. Edward Kasner, New York City.

Section B — Professor W. C. Sabine, Cambridge, Mass.

Section C — Mr. Clifford Richardson, New York City.

Section D — Mr. W. R. Warner, Cleveland, O.

Section E — Professor A. C. Lane, Lansing, Mich.

Section F — Professor E. G. Conklin Philadelphia, Pa.

Section G — Dr. D. T. MacDougal, Washington, D. C.

Section H — Professor Hugo Münsterberg, Cambridge, Mass.

Section I — Mr. Chas. A. Conant, New York City.

Section K — Dr. Simon Flexner, New York City.

Dr. W. H. Welch, professor of pathology in the Johns Hopkins University, was elected president of the association to preside at the Ithaca and New York meetings. His portrait is

GEORGE GRANT MCCURDY, Lecturer in Anthropology, Yale University; Chairman of the Section of Anthropology.

given as a frontispiece to the number. Here again the advance of science and the growth in the scope of the association are shown, as pathology and bacteriology are for the first time recognized in the highest honor that his colleagues can confer on a man of science. They are fortunate in knowing that there is a student of pathology in the country who is preeminent in his science, and as the same time a leader in all good causes concerned with his profession.

SCIENTIFIC ITEMS

We regret to record the deaths of Dr. William Rainey Harper, president of the University of Chicago, of Dr. Richard Hodgson, secretary of the American branch of the American Society for Psychical Research, and of Professor Charles Jasper Joly, F.R.S., astronomer royal of Ireland.

The committee appointed to carry the proposal of a memorial to Rudolf Virchow into effect has now a sum of $20,000 at its disposal. Of this amount $9,000 has been contributed by subscribers and $11,000 by the city of Berlin.—A memorial to Professor Albert von Köllicker will be erected in Würzburg by the German Anatomical Society, of which he was an honorary president.—A memorial medal in honor of Andrée has been made by Londberg, the Swedish engraver. The artist represents Andrée's balloon rising from the ice. The explorer is looking anxiously toward the north. A group of young men are applauding, while an old man looks toward the horizon doubtfully. Below is the date, July 11, 1897. On the obverse appears the profile of André.

A department of botanical research to include the Desert Laboratory and other botanical projects, was established by the action of the trustees of the Carnegie Institution at a recent meeting. Dr. D. T. MacDougal has resigned as assistant director of the New York Botanical Garden to accept the post of director of the newly organized department.—Major D. Prain, hitherto director of the Botanical Garden at Calcutta, has been appointed to the directorship of Kew Gardens, vacant by the retirement of Sir William Thiselton-Dyer.—Mr. F. W. Dyson, F.R.S., chief assistant at Greenwich Observatory, has been appointed astronomer royal for Scotland, in the room of the late Professor Copeland.

The will of the late Charles T. Yerkes, who owed his large fortune to the direct application of recent advances in science, makes provision for three important institutions, which are to bear his name. The Yerkes Observatory, to which he has already contributed liberally, receives $100,000, the Yerkes galleries and the Yerkes hospital are to be established in New York City, on the death of his widow, or sooner should she wish. The hospital will also be established in case of the death of one of the two children. After certain bequests to Mrs. Yerkes, to his son and daughter and to others have been made, a trust fund is established, most of which will ultimately go to the support of the hospital. It is said that the value of the house on Fifth Avenue to be used for the galleries is $1,000,000, and that the value of the collections is $4,000,000. $750,000 are provided as an endowment fund for the galleries, which will be under the control of the Metropolitan Museum of Art. The hospital, which is to be situated in the borough of the Bronx, will receive, it is estimated by the daily papers, from $5,000,000 to $16,000,000.

Fig. 1. View Eastward from Mt. Marcy—showing a dome-shaped summit at the right, and sharper wedges on the left in the middle distance.

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THE PHYSIOGRAPHY OF THE ADIRONDACKS

BY PROFESSOR JAMES FURMAN KEMP,
COLUMBIA UNIVERSITY

Introduction.—The state of New York is shaped like a shoe, with its toe pointing due west and a long spur extending from the heel to the east. In the upper part of the shoe where the ankle of the wearer would be placed, is the Adirondack region, containing 10,000 square miles of very sparsely inhabited mountain, plateau and forest. It embraces the highest summits in the state, and at the same time the highest in eastern North America, except the White Mountains of New Hampshire and the Blue Ridge of North Carolina. Were it not for these two, even though the Appalachian region is decidedly and impressively mountainous, the Adirondacks would remain the loftiest summits in the east; and the equal of Mt. Marcy, called Tahawus or the 'Cloud-splitter' by the Indians, would not appear on the hither side of the Black Hills of South Dakota or the remoter Rocky Mountains.

Geological Formations Present.—The Adirondack region in its geology presents an important and interesting series of Precambrian rocks. Roughly speaking, nearly the whole area consists of gneisses, but the metamorphic rocks can be separated into a great series of sedimentary gneisses, quartzites and coarsely crystalline limestones, on the one hand, and, on the other, into a second great series of eruptive syenites, granites and rocks of the gabbro family. Except for the limestones, all these rocks are hard and resistant, their weak points of attack being in a small degree their schistosity, and in a greater degree their joints and faults.

On all sides the Precambrian rocks are mantled with the Paleozoics, the oldest of which is the Potsdam sandstone of the Upper Cambrian, a hard quartzite, gray, pink and pale yellow in color. The latest member of the Paleozoics having any association with the old crystallines is the Utica slate, near the top of the Ordovician, while between the Potsdam and the Utica appear in order from below, upward, the Beekmantown, Chazy and Trenton limestones. Except perhaps the Utica slate and the Trenton limestone, which is somewhat shaly, all these are firm, resistant rocks. The visible contacts of the Paleozoic strata with the old crystallines, especially on the northwest and west, are often those of sedimentary overlap, due to an advancing shore line, but on the east and northeast they are much more frequently due to block-faulting of a most interesting character and exceedingly significant as throwing light on the physiography of the interior mountains. Aside from this, however, the Paleozoic strata enter only in a very minor way

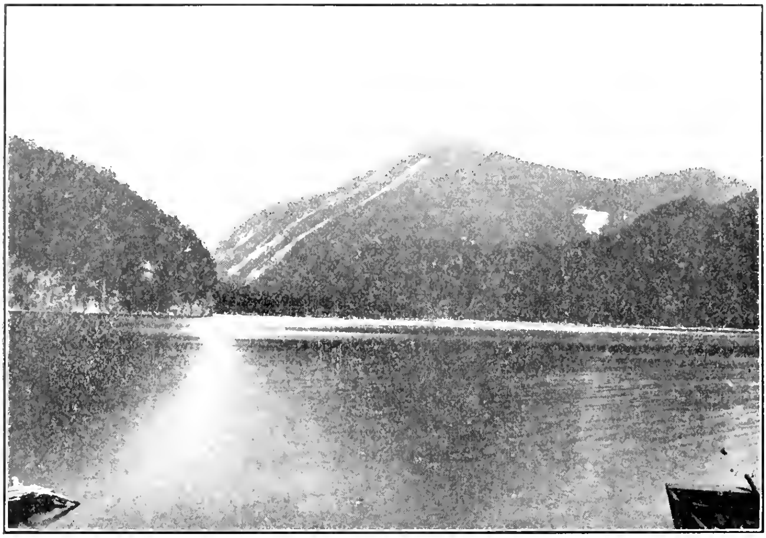

FIG. 2. MT. McINTYRE, THE SECOND PEAK IN ALTITUDE—viewed from the southeast. The side towards the observer is very steep.

into the structure of the mountains. They occur around the edges, except for a few isolated outliers from five to forty miles within the Precambrian area.

After the deposition of the Utica, so far as the actual evidence is concerned, there were no more rocks laid down until the advent of the Labradorean ice sheet of the Glacial epoch. Whether later Paleozoics once existed and have been removed by erosion, or whether the area has been continuously land from the close of the Ordovician to the present, may be esteemed to a certain extent open to debate. From observations near Little Falls on the southern side, Professor H. P. Cushing has concluded that the Niagara limestone probably extended a long distance into the area of the crystallines if not entirely across. But no trace of it has been discovered in place, and the great gap in time from the Ordovician to the Glacial epoch must be interpreted, if at all, by the structural and physiographic records. The Labradorean ice sheet was, however, of enormous importance. Its deposits are heavy, and it doubtless operated to form numberless lakes and to greatly reorganize the drainage, as will be later pointed out in a few suggestive instances.

The Mountains Proper and the Western Plateau.—The Adirondack region, sometimes referred to as the Great North Woods, is mountainous in its eastern half, and has its highest peaks near its center, but on the west the mountains disappear and the area becomes a plateau ranging from 2,000 feet above tide gradually downward to the west until it is but slightly higher than Lake Ontario and the St. Lawrence. The

FIG. 3. MT. WHITEFACE FROM FRENCH'S HOTEL ON THE NORTH. Steep and narrow passes bound it on either side.

loftiest peak is Marcy, 5,344 feet, and there are one or two others which exceed 5,000, together with five or six additional above 4,500, and many above 3,000. The mountains are ranged in visible northeast and southwest lines, and are often very steep if not positively precipitous in the portions that look to the southeast or northwest. There are also other steep faces nearly at right angles with the above, but they are less pronounced. When viewed from a distance the profile is strongly serrate —a gradual slope up on one side being cut off abruptly by an almost vertical descent on the other.

The individual mountains are diversified in shape. Mt. Marcy is a very low cone, and the last stages of its ascent are very much like climbing a dome. Mt. McIntyre has a gradual slope from the northwest,

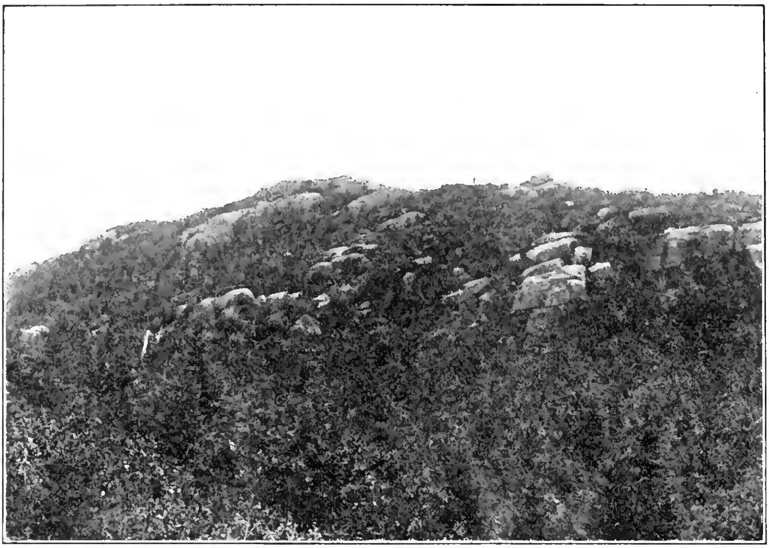

FIG. 4. MT. HURRICANE FROM THE WEST, a relatively flat summit.

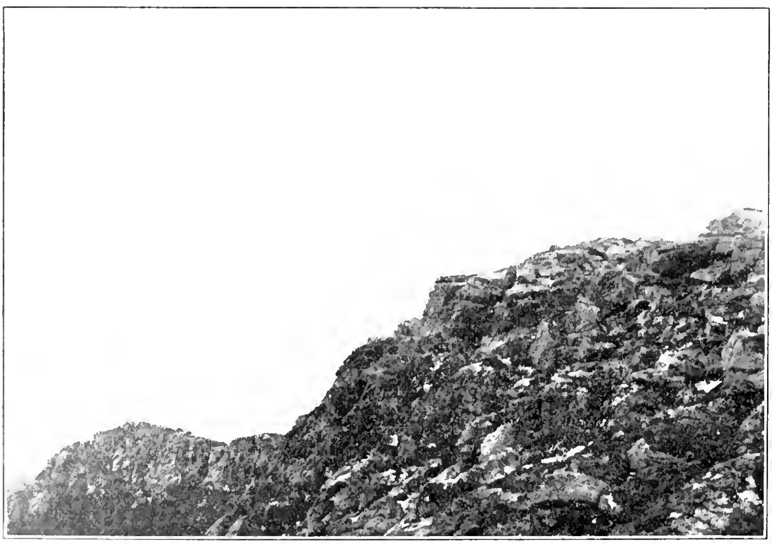

FIG. 5. THE SUMMIT OF MT. WHITEFACE ILLUSTRATING THE WASTING-AWAY ALONG JOINTS.

but a precipitous escarpment on the southeast. The Gothics are like a steep wedge standing on its base, and tapering from all four sides of the base to the ridge. Whiteface is a long sharp ridge, steep if not actually precipitous on each side, and leading up to a peak at the southwestern end. Some buttresses run out from the ridge and make beautiful cirques on its flanks. Hurricane, when viewed from the east, resembles a sharp volcanic cone; from the west it is flat. There are several, of which Dix is the highest example, which, like Vesuvius, have a small conical summit set upon a large mountainous base. Nippletop is a rather favorite name in the local nomenclature of the inhabitants. There are several smaller mountains which have the outlines of a steep haystack when viewed from certain directions, and their precipitous sides and doming tops fix the eye at once. Yet they may each be a ridge when seen from the opposite. One very exceptional peak, quite inappropriately called Sugarloaf, near Hulett's on Lake George, is a circular mesa, with a flat top several acres in area and dropping with steep sides to the lake slope below. It resembles a round fort or old-time castle, such as St. Angelo, across the Tiber from Rome, or Castle William on Governor's Island in New York Harbor. It is due to flat foliation in the gneisses combined with intersecting vertical joints. Not a few other mountains, although of very irregular shapes at the base, yet have flat tops of considerable area. Their level summits appear to be the surviving remnants of some old-time peneplain now faulted into relief, as will be later explained.

The plateau portion, which makes up practically the western half, is not absolutely flat, but is more or less diversified with low hills and intervening broad valleys. Occasional summits give views of moderate extent, but no elevations can properly be called mountains, and the general term plateau is most expressive. It may well be the remnant of an old peneplain, perhaps the important one widely developed in Cretaceous time in the east.

The Valleys.—The mountains can not all be described without parallel and complementary reference to the valleys, and in discussing the latter the causes which have led to the production of the former may best be mentioned.

At least two marked and contrasted types of valleys may be distinguished. There is an old series which in part probably dates back even to Precambrian time. In the eastern mountains the cause of their excavation is oftentimes obviously the presence of relatively soft and easily eroded limestone in the series of gneisses. In several notable cases the Potsdam and even later Paleozoic formations can be traced by the remaining outliers some miles into the old crystallines, and although subsequent faulting has exercised its modifying and disguising influence, yet it has appeared to several observers that the old

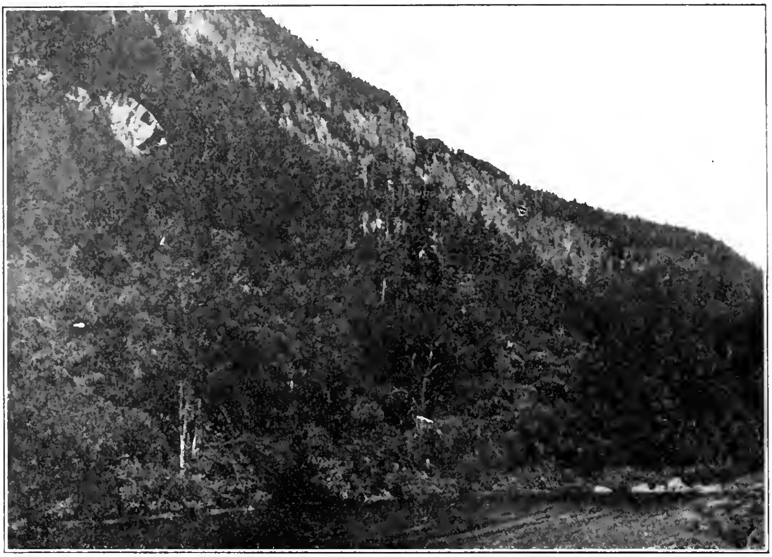

FIG. 6. PRECIPITOUS CLIFFS ALONG THE NORTHWESTERN SIDE OF THE WILMINGTON NOTCH—illustrating the northeast and southwest type of fault valley.

depressions were recognizable. The old valleys have gentle slopes and wide expanses. Their contours are softened down and the whole physiographic expression is one which suggests long-continued erosion and maturity of form. In studying out these relations, one has also to eliminate as far as possible the mask of glacial drift which is everywhere in evidence. The valleys of the old system run in their most marked development east and west, and north and south. Several of them are occupied to-day by some of the largest streams and lakes—such as Schroon lake, the southern third of Lake George, parts of the Hudson Valley and several tributary to Lake Champlain. One half of an old valley will often remain with characteristically gentle slope and mild topography, while the other half of the depression will consist of the steep precipices of the next type. And as the second type has been superimposed upon the first, the observer is often forced to trace the former out despite its disguises and modifications.

The second type of valley is obviously the result of faulting, and of faulting that is of no great geological antiquity. The sides and steep escarpments and the depressions may have all the characteristics of a 'Graben-senkung,' or of a fjord, if the latter can be imagined away from the sea. In the southeastern portion of the mountains as well as in the interior, three pronounced sets of fault escarpments may be recognized and plotted. The most marked one is northeast, and to it is due the general northeast and southwest trend of the mountains. The topographic maps, and still more the relief model prepared by

E. A. Howell, show this in all desirable clearness. Along the shores of Lake Champlain the ridges come in one after another from the southwest, making the western shore of the lake a series of bays with bold intervening headlands. The central portion of Lake George, where the wildest and most picturesque scenery is found, is another example. Precipitous escarpments characterize the shores, while mountains of rugged outline shut in the observer. In the interior these characters appear on an even grander scale. The Lower Ausable lake is a Graben; Avalanche lake, one of the sources of the Hudson, has cliffs so steep that the traveler must take to a boat to find a passage. In Wilmington notch, as also in Indian pass, cliffs hardly less than a thousand feet, front the traveler.

A second but less strongly developed series of faults runs northwest and southeast and is the cause of many cross breaks at right angles with the set last mentioned. They serve to block out the individual mountains amid the general northeast trend of the ridges, and are responsible for innumerable little cross-passes which are found on all the summits. In the high mountains, the little cross-passes almost always have a well-defined bear or deer trail following them through. They serve also to develop sharp shoulders in the precipices of the first type and to give the shores of a lake a very serrated outline. In the Mount Marcy and Elizabethtown quadrangle they, with the first set, have occasioned the interesting 'lattice-shaped' drainage noted by Professor Brigham some years ago. The little streams flow

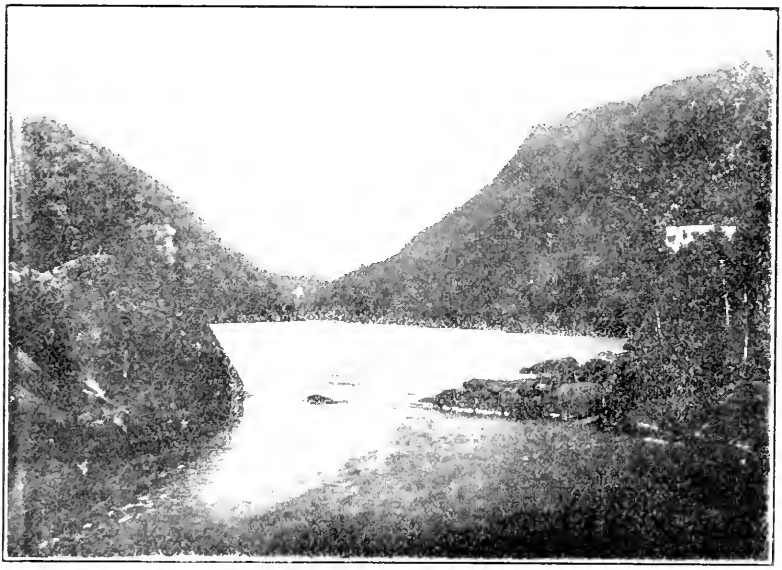

FIG. 7. THE CASCADE LAKES, BETWEEN THE KEENE VALLEY AND LAKE PLACID—illustrating the northwest and southeast faulted valley.

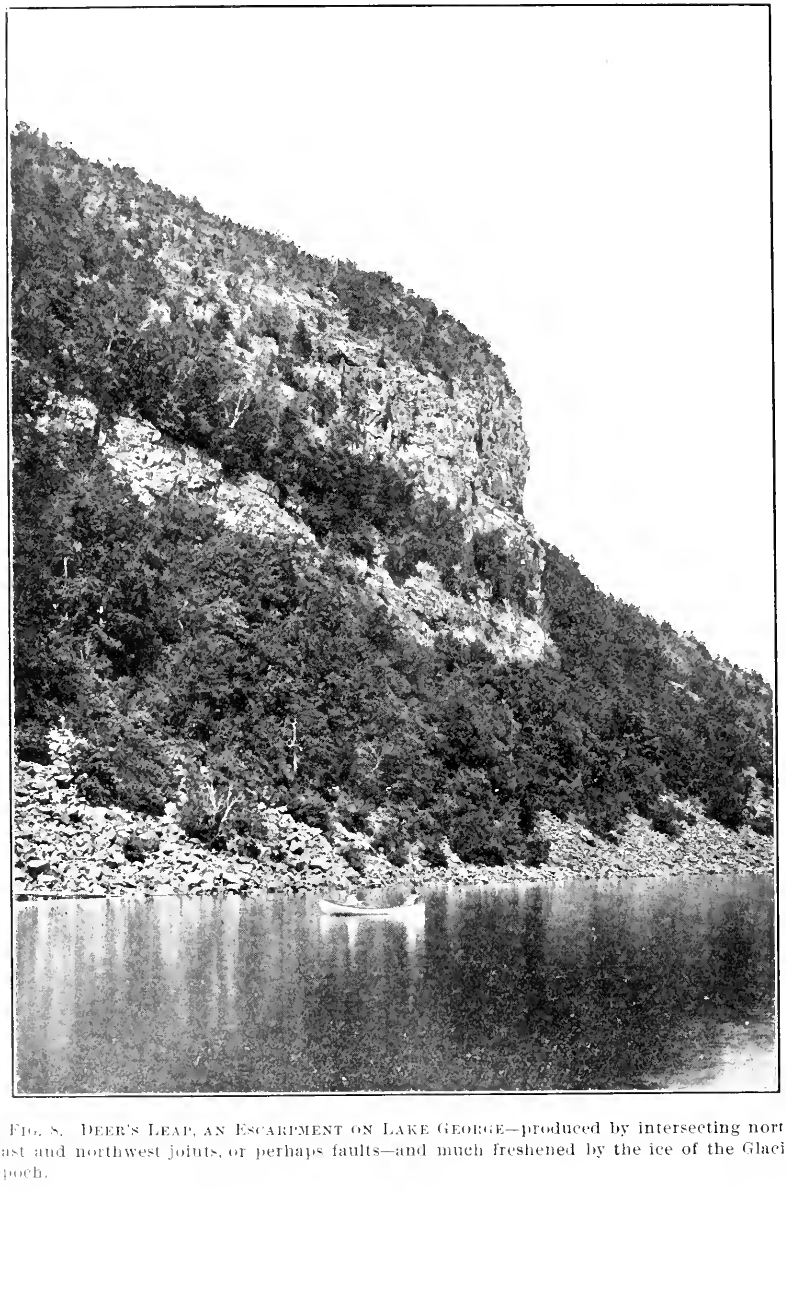

FIG. 8. DEER'S LEAP, AN ESCARPMENT ON LAKE GEORGE—produced by intersecting north-east and northwest joints, or perhaps faults—and much freshened by the ice of the Glacial epoch.

down moderate slopes from the northwest, against high and sparsely wooded precipices on the southeast and join larger streams which flow northeast or southwest. When a wide area is studied, it is only the older and still surviving east and west or north and south valleys which break up this lattice-like regularity.

In less frequent occurrence than the northeast and northwest fault breaks, minor ones ranging nearly due north may be recognized—but they do not exercise so important an influence on the general relief.

The three systems of faults have in some instances led to great single precipitous escarpments suggesting that the movement was chiefly confined to one single plane, but it is much more common to find the fault a compound one. That is, a very steep mountain face will consist of a series of small escarpments, each with a bench at its foot. These benches make terraces, and on Lake George one can easily see, even when the mountain is thickly forested, that the trees are growing in pronounced rows with thinner lines of vegetation between. A mountainside may thus look like a gigantic series of furrows, as is true of the ridge from Black Mountain to Elephant Mountain. Where the faults cut across a projecting shoulder the terraces go up one side and down the other like a series of lunettes. Forest fires and the lumberman's axe, while destroying much of the beauty, have yet brought out these features with striking emphasis, and when the light intensifies the relief with shadows they appeal to the observer in the strongest way. The narrow ridge between Lake George and Lake Champlain contains some of the roughest country in all the Adirondack region.

The faults and their escarpments were doubtless much freshened up by the Labradorean ice-sheet which plucked away from their faces the loose rock, sheeted by the parallel faults. In this way the relief was heightened during the Glacial epoch, and its freshness and youth still remain to us, but the faults preceded the ice and were the great governing factors. Thus far no evidence of post-glacial faulting has been observed.

On the south side of the mountains the faults run out in a striking way into the overlapping Paleozoic areas and have been traced as much as thirty or forty miles. One famous one causes the Precambrian rocks on the west to abut sharply for thirty miles against the Cambrian and Ordovician strata, forming an escarpment which faces east. After the Precambrians have disappeared below the Paleozoics for two miles, they rise again into view at the pass called the 'Needles,' where the Mohawk river, the Erie Canal and the New York Central and West Shore Railways find a way close together fifty miles west of Albany. Another is responsible for the Precambrian outlier of Little Falls, recently described by Professor H. P. Cushing. The displacements exhibited in these easily recognized and contrasted strata are of great significance when taken as illuminating the more obscure relations of the Precambrians of the interior mountains.

One interesting corollary of the great northeast and southwest breaks is that a series of basaltic dikes which are widely distributed, which followed the metamorphism of the Precambrian rocks, but which preceded the Potsdam, almost always come up through them and suggest that the breaks go far enough down to have tapped off a reservoir of basic rocks.

The Drainage.—The waters from the Adirondacks flow into both the Hudson and the St. Lawrence Rivers. On the south and southwest they either go directly to the former which rises in their very center;

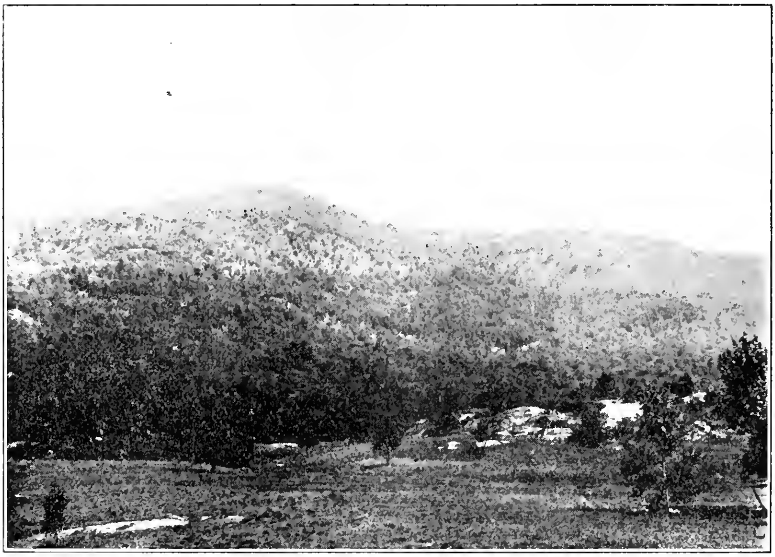

FIG. 9 SPRUCE MOUNTAIN, NEAR HULETTS, LAKE GEORGE—and viewed from the northwest. A fault—escarpment faces the observer.

or else they pass first through the Mohawk. On the north and east, the waters reach the St. Lawrence *viâ* Lakes George and Champlain, and on the northwest *viâ* Lake Ontario or directly to the great river itself. The drainage of the high mountains, however, goes almost entirely to the Hudson or to Lake Champlain.

The chief rivers actually in the area are the Hudson and its principal tributary north of Waterford, the Sacondaga, both of which will be shortly described in greater detail; West Canada Creek, and minor tributaries of the Mohawk; the Black, flowing into Lake Ontario; the Oswegatchie, Grass, Raquette, and Salmon-Chateaugay, which pass directly into the St. Lawrence; and the Saranac, Ausable and the outlet of

Lake George directly into Lake Champlain. Some of these are largely, if not essentially, preglacial in their courses, occupying the earlier valleys mentioned above. Others have been obviously influenced in their present locations by the glacial deposits. It is clear from the insuperable rocky obstacles presented that drainage must even in the preglacial period have radiated from the central height of land, and that there is a marked preglacial divide around Mt. Marcy which at this time separated the waters going north from those going south. But there are some strange features about the present courses of the Hudson and Sacondaga and some interesting points about Lake George which will be briefly noted.

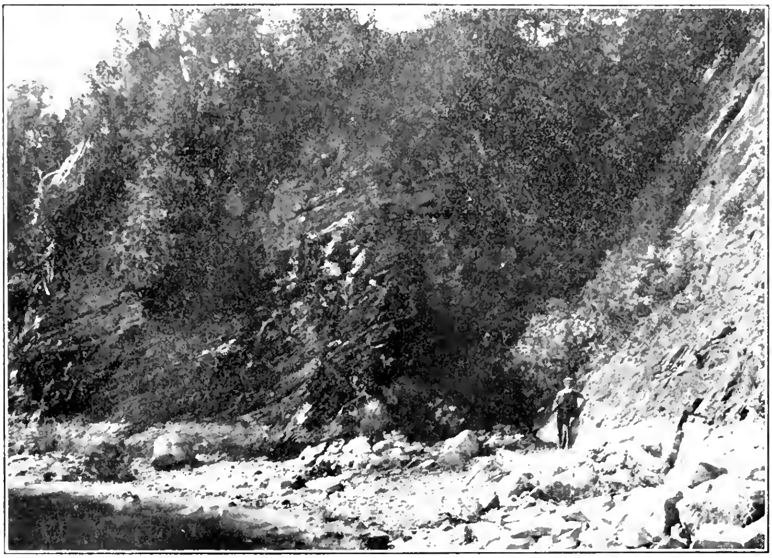

FIG. 10. A FAULT IN PALEOZOIC STRATA NEAR ESSEX, N. Y., ON LAKE CHAMPLAIN. The Utica slates, from flatness on the left beyond the picture, are dragged to a fairly steep inclination, where faulted against the hard Beekmantown limestone, which lies several hundred feet below in the stratigraphic series.

The Hudson gathers its waters first from a series of beautiful mountain lakes almost under Mts. Marcy and McIntyre, the loftiest two peaks, and flows nearly due north for fifteen miles, following, no doubt, one of the older north and south valleys. It then turns abruptly westward, winding for five miles amid hillocks of drift, and tapping a notable series of east and west lakes near Newcomb village, doubtless impounded in one of the old east and west valleys. It then turns nearly due south for ten miles and makes an abrupt bend, of somewhat less than ninety degrees, to the eastward, being apparently diverted into an east and west valley by a barrier of drift. Just after it makes the turn it receives the waters of Indian River coming from a drift-

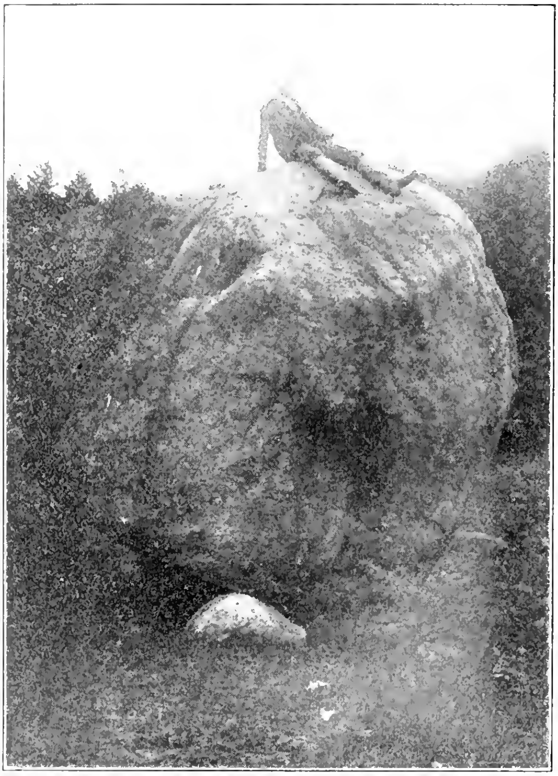

Fig. 11. A Glacial Boulder in the Keene Valley.

covered, open and swampy area to the southwest and directly in the line of its previous courses. It is apparently a case of reversed drainage. After a somewhat sinuous easterly course of eight or ten miles, the Hudson turns again abruptly south, receiving at the same time the Boreas River, which comes in from the north with the waters of a broad, open region much masked by drift and filled with swamps and lakes. It would seem as if the Hudson had jumped thus from one older drainage line to another. The Hudson next flows due south for four or five miles, then turns once more eastward, for eight miles, then south and southeast until it again turns eastward, northward and finally eastward with marked meanders across the great sandy plain near Glens Falls. Finally at Sandy Hill it swings around once more to the south and takes its nearly uniform course for the sea.

The Sacondaga River has also this same peculiar rectangular bending from north and south to east and west courses, and with a most peculiar turn parallel in all respects to the bend of the Hudson, it swings into the latter some miles above Glens Falls.

These bendings are in large part to be explained by the old series of east and west and north and south valleys and by the rearrangements of the older drainage by the glacial drift. When the streams sought to occupy their old north and south channels on the retreat of the ice they seem to have been forced in instances by newly acquired barriers to run in an easterly direction across old but low divides and then to utilize parallel north and south lines of drainage.

Lakes.—The Adirondack region, like all the recently glaciated country, teems with lakes which can be observed in all stages from those of large size like Champlain, George and Schroon, through smaller ones, to those little more than a morass, and finally to cultivated meadow land upon the abandoned bottoms of departed ones whose deltas and terraces stand out clearly. Lake Champlain is the largest and has a total length of 150 miles. It has been recently studied in detail by Professor J. B. Woodworth. It is obviously an old river valley, probably modified somewhat by recent faulting and ponded by some barrier of recent formation at the north. Lake George is next in size and is apparently compounded of two earlier valleys, whose divide

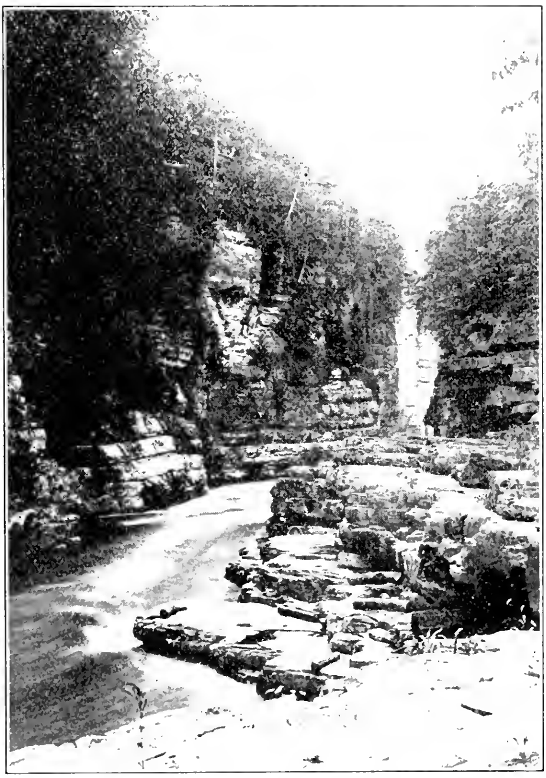

Fig. 12. Ausable Chasm, whose zig-zags are due to faults and joints. The walls are hard Potsdam quartzite.

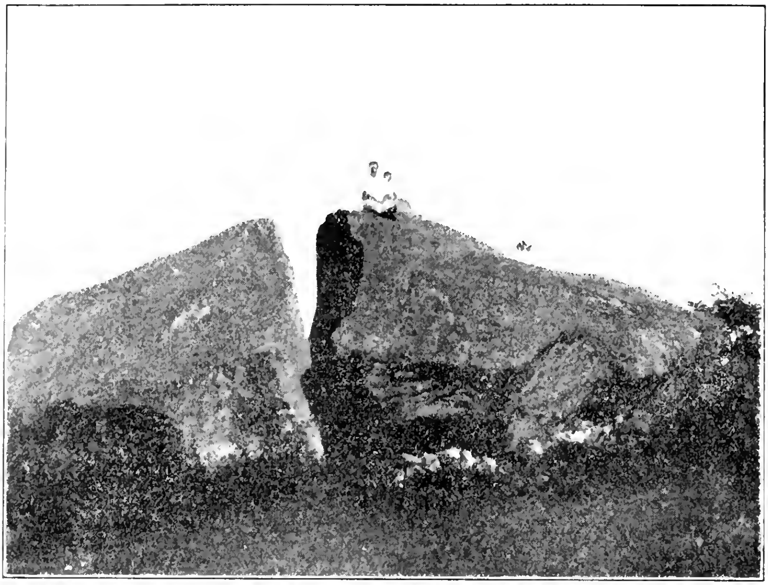

FIG. 13. CLEFT GLACIAL BOULDER NEAR HAGUE ON LAKE GEORGE.

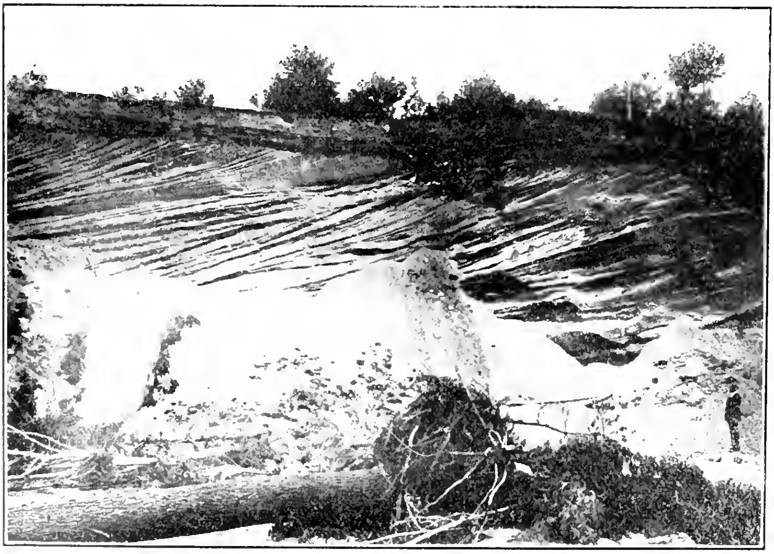

FIG. 14. AN OLD DELTA NEAR ELIZABETHTOWN FRESHLY EXPOSED BY A HEAVY FRESHET.

was near the Hundred Islands about midway of its length. One old valley headed up in Northwest Bay, and the other probably did not come much south of Sabbath Day Point. Faulting connected them, however, and the damming by the drift of the old outlet to the south at the head of Kattskill Bay and of the normal outlet to the north into the Trout Brook Valley or possibly eastward into Lake Champlain at Blairs bay, produced the present composite lake, with its precipitous mountainsides and wild rugged scenery. The old relations are greatly obscured by the glacial drift. Schroon Lake is another ponded and drowned river valley, with both a sluggish outlet and a sluggish inlet, the former with wonderfully developed terraces on either side, running like railway embankments as they mark old periods of high water. The other notable series of lakes, like the Fulton Chain, have been produced by the drift in the old valleys, which were the great drainage lines before the glacial epoch. With moderate portages they can be navigated long distances.

Some of the smaller lakes are in fault valleys and not infrequently are on the divides so as to be the sources of the streams. The Cascade lakes (Fig. 7) between the Keene Valley and Lake Placid are good illustrations. Although now two, they were once continuous and have evidently been divided by a landslide.

The Ice Invasion of the Glacial Epoch.—Coming after so long an interval during which the Adirondack area was land the Labradorean ice sheet possesses exceptional interest. All the scratches so far observed and recorded point to a source on the northeast. The glacier advanced from this quarter, and, as has been shown in some detail by Dr. I. H. Ogilvie, rode over the highest mountains and apparently filled the valleys with stagnant ice, since, except in the borders, scratches are rare. In fact the Paleozoic strata, in the lower confines, where the Champlain clays soon buried and preserved the scratches, are the most prolific sources of observations. The hard Precambrian rocks have mostly lost them by weathering.

The ice sheet must have found the Adirondacks covered with a heavy mantle of the products of decomposition. The long time during which the mountains had been land could have had no other result than this. It also found them of rugged topography much as now, because if we believe or assume, as is reasonable, that the Cretaceous peneplain was broken up into the flat-topped blocks by the preglacial faulting, the region must have presented a very irregular barrier in the pathway of the ice. The ice has left not a few characteristic topographic forms as the result of its action. Cirques appear on the flanks of several of the higher mountains, as, for example, on the northwestern side of Giant and the eastern side of Whiteface. Projections of the ridge run out in each case at right-angles to the main axis, affording a depression which must have had its own small glacier on the waning of the ice. This small glacier has eaten back against the main ridge so as to leave the characteristic cirque with its precipitous head.

Near Mt. Marcy, in the Paradox Lake quadrangle, Dr. Ogilvie has noted very perfect and striking cases of small rock basins, which the writer has seen under her guidance. Each is occupied by a small mountain lake, and is a bowl produced by plucking and scoring. Giant kettles or potholes are to be seen in many places around the northern shores of Lake George, and more particularly two or three miles north of Hague, where they are locally called Indian Kettles. There must have been sinkholes in the ice sheet at these points, which are now above the level of the lake, and torrents poured into them until the moulin or mill was established.

While moraines and huge transported boulders are not altogether lacking, yet they favor special localities and, generally speaking, the boulders are of but moderate size. The Potsdam sandstone furnishes a material of special interest, since it can be easily recognized, can be referred to its parent ledges and is found all over the mountain tops.

The larger boulders are a quite marked feature to the west of Schroon Lake Post Office, and from a distance resemble small houses. One now cleft in twain near Hague, on Lake George, is fully thirty feet in diameter (Fig. 13). With the waning and retreat of the ice, lakes were impounded in not a few of the valleys and their surfaces reached to altitudes high above the present bottoms. Near Elizabethtown in the valley of the Boquet River, and in the Keene Valley along the east branch of the Ausable River the deltas formed by tributary streams are still very clearly preserved, cut in two as is usual by the downward erosion of the present stream. Ice must have largely formed the barriers. Other and usually small lakes, as has been noted by Professor C. H. Smyth, Jr., have reached the state of morasses or meadows, affording the so-called vlies of the early Dutch settlers.

With the waning of the great ice sheet the vegetation crept northward, covering moraines, sand-plains and hills with a coat of green. At first obviously Arctic in character as the little colonies of hardy plants still holding out on the mountain tops show, the flora and silva assumed gradually a more temperate aspect and prepared the Great North Woods to be the chief recreation ground for the people of New York and neighboring states.

THE BLACK LOCUST TREE AND ITS DESPOLIATION.

By CHARLES A. WHITE,

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WITHIN the past few years an increasing interest has been manifested in the black locust tree, *Robinia pseudacacia*. Many persons have begun to propagate it, not only as a wayside tree, but as a forest product; and issues of the public press lately have contained many articles and paragraphs pointing out the excellent qualities of the wood and recommending its general cultivation for economic uses. Several of the articles referred to have mentioned the fact that one of the great railroad companies has, within the past two years, planted on its Pennsylvania lands nearly a million and a half of trees of this species with the intention of using the product for railroad ties and fence posts, and for other purposes requiring exceptionally durable wood. It has been publicly announced that large additions to that company's planting of this tree are to be made, and it is also known that many smaller, but still extensive, enterprises of this kind, under both corporate and individual management, are in progress in different parts of our country. The aggregate of these enterprises requires the expenditure of so much labor and money before any profitable returns could be expected, that one who is acquainted with the past history of the tree can not but wonder at the apparent lack of business precaution, or of sound advice, which they imply. The fateful destiny of this tree has been long known and until recently it has been generally neglected; but by most persons the facts concerning it apparently are now forgotten or disregarded. From personal observations, extending through many years and over a large part of the United States and adjoining parts of Canada and Mexico, I am convinced that all attempts to cultivate this tree in any part of North America, with the possible exception presently to be mentioned, will result in failure so far as suitable returns in practical value of the product is concerned. The subject therefore has, with comparative suddenness, become of public importance, and my chief object in writing this article is the utterance of a public caution concerning it, especially directed to industrial interests.

The excellent quality of the wood of this tree is all that has been claimed for it, and doubtless it is this quality, together with the knowledge of the vigor of its early growth, that has encouraged the extensive preparations that lately have been made for its artificial propagation. Our soils and climate are almost everywhere well adapted to its growth, its abundant seeds germinate readily, and it responds promptly to the forester's care. The danger of failure in growing this tree for economic uses lies, not in the character of the tree nor in that of our soils or climate, but in the persistent attacks of destructive insects which are natives of the same region with the tree, which follow it in its geographical distribution, and which presently will be further referred to.

There are two North American trees which bear the popular name of locust, the one already mentioned and the honey locust, *Gleditschia triacanthus;* but it is only the black locust that is referred to in these remarks. This tree originally was known only in that region which lies east of the Allegheny Mountains and between New York and Louisiana. By natural dispersion and artificial propagation, however, it has grown for many years more or less commonly, but for the most part unthriftily, in nearly all the eastern half of the United States, as well as in other parts of North America. Early after its first discovery its seeds were carried to other countries, where the tree was successfully progagated from them. In Europe, especially, where its American insect despoilers never have been introduced, where the indigenous insects never molest it, and where it readily adapts itself to the local climatic and terreous conditions, it has always grown thriftily and symmetrically, reaching a maximum size comparable with that of the oaks. Being there esteemed as an ornamental tree, it is often grown in public parks, and it is also much cultivated in preserved forests for its valuable wood.

This European experience with the black locust tree well illustrates its extraordinary vigor and its ability to reach full maturity of growth under a wide diversity of conditions of soil and climate. Its completely successful growth to trees of medium size in formerly isolated North American districts west of its native regional habitat, and its persistent struggle for existence against its insect despoilers wherever it has been established in our country show that our soil and climate are entirely favorable to its growth and that it is only accessory, but dominant, conditions that are unfavorable. These accessory conditions are now known to be the result of ravages upon the living parts of the tree by the insects referred to. Indeed this tree presents the remarkable case of a strong arboreal species doomed on its native ground and in contiguous regions, to a constant state of suppression of its natural development, and even to local extermination, by insect despoilers which are natives of the same region with the tree and wholly dependent upon it for their own existence. There is no other North American tree, perhaps, excepting the common mezquite of our southwestern states and Mexico, which is so disastrously damaged in its growing condition by indigenous insects as is the black locust, and both of these trees would be of very great industrial value if it were not for the ravages of those insects. Other insects, the imported gypsy moth for example, commit their terrible ravages upon the foliage of different kinds of trees indiscriminately, but the insect pests of the black locust and the mezquite are indigenous, and each species attacks only its own destinate tree. The chief injury to each of these trees is done by the larvæ which burrow in its living wood.

There are at least three species of insects which injure the black locust tree. The small larvæ of one of them tunnel the parenchyma of the leaflets, and another species produces a gall-like enlargement of the tips of tender twigs as a result of depositing and hatching its eggs there. But worst of all, the large, vigorous and abundant larvæ of one of the longicorn beetles, *Cyllene robiniæ*, burrow throughout the wood of the entire trunk and larger branches, rendering it unfit for economic uses. All these insect species are known to be dependent for their own existence upon the black locust tree because all three of them deposit their eggs nowhere else than in its tender tissues; all three of them pass their entire larval stage, the only stage in which the insect really increases in growth, in its living substance, and all three of them derive their only incremental nourishment from that tree. If, therefore, the black locust tree were exterminated, all those insects would necessarily perish; and if all those insects were first exterminated we should have restored to us one of the most valuable of our forest trees. But none of those contingencies is likely to occur.

Great damage is sometimes done to the black locust tree by the two insect species first mentioned, but usually their depredations are so much less disastrous than are those of the tree borer that, for only the present occasion the two former species may be regarded as negligible and only the latter need be specially noticed. Because this article is written with reference to a matter of public interest it is thought desirable to give a brief popular account of the characteristics and habits of that destructive insect. The beetle, which dies naturally soon after the function of reproduction is completed, is nearly an inch long, somewhat slender, and has a pair of slender curved antennæ as long as the body; and the larva is a vigorous grub nearly or quite as long as is the beetle. The metamorphosis from the larva to the pupa stage and from that of the pupa to the imago or beetle stage occurs as the insect is about to emerge from its burrow in the tree; the final change and emergence beginning to occur in late summer and continuing through autumn. The beetles soon mate and hover about the Solidagoes and other late flowers, feeding scantily and harmlessly upon the pollen. The females immediately seek the black locust trees by flight, pierce the bark and deposit their eggs in the soft cambium layer beneath it. The resulting larvæ burrow at once into the tree, traversing the wood of the trunk and larger branches in all directions. The insect there completes the annual cycle of metamorphoses and emerges as a beetle of that generation about a year after the egg is hatched. The burrows are made by the strong horny jaws of the larvæ, which shred every particle of the wood in the course of the burrows, all of it passing through the intestinal canal of the larvæ. Only the scanty protoplasmic contents of the wood cells, however, are digested for nourishment, and the dry refuse, resembling fine saw-dust, is packed behind the larva as it progresses in its burrow. The burrows are comparatively large and when numerous, as usually they are, they cut across the wood fiber so frequently that the trunk and larger branches are often completely riddled by them.

Such is the condition to which the wood of the black locust tree is habitually reduced by those insects and to which it is the special object of this article to call public attention. It is almost needless to add that such burrows render the wood useless for timber, of little value as fuel, and more subject to decay than is the uninjured wood. Many and various kinds of insects burrow in the dead wood of different kinds of lumber and fuel and thereby do much injury, but comparatively few species bore exclusively in living wood, and these are extremely injurious. The destructive borer of the locust tree and the smaller but hardly less destructive borer of the mezquite tree, already mentioned, are two of the best-known examples of the latter kind. Perhaps the best-known example of the former kind is the hickory wood borer, which householders often find in their fuel; especially that which has been felled in late winter or early spring. These borings in hickory wood are closely like those which are made in the living locust trees, and the locust and hickory borers are so nearly alike in appearance in all three of their metamorphoses that it is difficult for the ordinary observer to distinguish them apart. The hickory borer, however, burrows only in recently felled dead hickory wood, its incubation therein beginning in the spring; while the locust borer burrows only in the living wood, its incubation beginning in late summer and continuing until frosts prevail. This last-mentioned fact is important with reference to any remedies against the ravages of the locust borer that may be proposed. Hickory wood which is felled in autumn or early winter is likely to escape its borers by becoming too dry to serve their needs when they reach the beetle stage in the spring; but for the locust tree, after its sapling stage, there is no immunity from its borers so long as it lives.

Apparently there are several reasons why the ravages of the locust borer have largely escaped popular attention, such as the destruction of fruit and foliage by insects receives. The bark of the tree usually remains intact long after the wood beneath it is greatly injured. The small pits and punctures which are made in it by the female beetle for depositing her eggs are not ordinarily noticeable, and even the holes by which the beetles escape from the burrows are not conspicuous. While the bark remains unbroken the tree lives and usually continues annually to produce its seed. The latter fact not only belies its hidden trouble, but it is characteristic of the strong vitality of the tree. This vitality is also exhibited by the roots which send up vigorous suckers, especially after the borers have attacked the trunk. Again, the reciprocal relation of the tree and the insects which prey upon it, although it is never wholly interrupted, is of more or less unstable equilibrium, sometimes the tree, and sometimes the insects being ascendant. That is, it has often happened in a given district that the tree became reduced in numbers to a few scattered and injured specimens, and its insect enemies were correspondingly reduced in numbers because of the reduction of their only means of subsistence. The native vigor of the tree then gives it such advantage that it so thrives again that one naturally hopes for its permanent immunity. But that improvèd condition of the tree itself invites, and sooner or later receives, renewed attacks of the insects, which lurk there or which come in from contiguous districts. Such an oscillation of relative conditions occurs with the borer especially, thus deceiving local observers as to the great average damaged condition of the tree. The two insect species which have been mentioned as preying upon the leaves and tender twigs respectively have their needs supplied by even the youngest, as well as the older, growth of tree, but the borer requires a body of living wood of some inches in diameter in which to produce burrows of sufficient extent for its needs. Therefore this greatest of the insect enemies of the black locust tree is held at bay until the tree has reached sufficient size for boring, during which time the planter must await the issue. Meantime the young of this tree generally grows as thriftily as the average of other trees, and often it produces seed before it is large enough for the borers. It is not strange that this early thrift of the tree should encourage disbelief of impending evil for it, but the facts here mentioned are too well established to admit of serious question.

Exceptionally large and healthy specimens of the black locust tree are sometimes found growing as a part of the native arboreal flora, their, at least partial, immunity from insect injury doubtless being due to local causes, some of which are obvious and some obscure. For example, some of the best American specimens of the tree are found to have grown in, or around, cattle-pens, barnyards or other farmstead inclosures where domestic animals are gathered, the conditions of which places are known to be favorable to the tree, and they are apparently unfavorable to the insects. Again, the isolation of the tree by planting its seeds in districts remote from those in which both the tree and its insect enemies prevail, has resulted in the healthy growth of the tree for many years; but in most of such cases the trees have been overtaken by the borers and destroyed or rendered valueless long before they could have reached the full size of which the species is capable. My present information indicates that there are yet some districts in the western part of the United States, notably portions of California, in which the black locust tree, which was originally grown there from eastern seed, has not yet been injured by the borers. But the borers are surely lurking in all other parts of our country in which that tree has grown for any considerable number of years. Furthermore, judging from the facts already stated and the remarkable case of destruction of that tree by the borers which occurred in the great valley of the Upper Mississippi between forty and fifty years ago, one may reasonably fear that those farther western groves will yet suffer like disaster.[1]

The case referred to is peculiar, and fraught with important suggestions to those who are now contemplating the artificial propagation of the black locust tree. In the early half of the past century there occurred a strong migratory movement of families overland from eastern states to Illinois and Iowa, who carried with them in their wagons the seeds of various kinds of trees, among which were those of the black locust. Those seeds were planted in the fertile soil of the new homesteads, where they germinated promptly and the seedlings grew vigorously and healthfully. The settlers thus 'stole a march' of many hundred miles on the borers, for neither they nor the tree upon which they exist had then occupied a large part of the country which the emigrants traversed. The seedling trees of the earlier settlers soon reached reproductive maturity and furnished abundant seed for further planting. The streets of the towns and villages were bordered with the trees and the farmers who possessed prairie land planted groves of them with the expectation of using the product for much-needed fence posts, and for other purposes. But while the trees were rapidly increasing in size by healthy growth, ominous reports began to reach the settlers that the borer was moving westward and, finally, that it was approaching the great region in which they had made their homes. In due time the borers arrived there, for the intervening country eastward had become so dotted with artificial groves of the black locust tree that the insects in their beetle stage, easily spread from grove to grove by natural flight. None of those trees in the Mississippi valley had then reached the maximum size of the

[1] A personal communication from Mr. A. E. Schwarz, of the U. S. Department of Agriculture, who has long made special studies of the habits of these insects, confirms my own observations as to the extent and imminence of their ravages. He thinks, however, that the Locust borer possibly may not invade our Pacific Coast region because the insect fauna there being so different from that of which the borer is an original member is likely to prevent its geographical range over that region. He thinks it probable also that a similar faunal influence has prevented the introduction of the borer into Europe, where the tree has been so fully acclimated.

species, but they had fruited for many years, and some of them had reached a foot or more in diameter at the base. They had grown so thriftily that their continued growth was naturally expected by those who had planted them; but when the borers came the trees were everywhere injured or destroyed as by a pestilence. Within a very few years after the first appearance of those insects in that western region nothing remained of the almost numberless groves and rows of those trees except their blasted remnants and the young shoots that the vigorous and unconquered roots were striving to bring forth. That condition remains there to this day, essentially unchanged except that even the stumps and roots of the blasted trees have, from time to time, been removed to reclaim for other uses the soil which they formerly occupied. Because of that wide destruction one may now go many miles in that great region without seeing more than a few neglected outcasts of that once popular tree; just enough to afford breeding places for a few of the hardy and prolific borers, which are always ready to commit their ravages. I was an eye-witness of that great destruction from its beginning to its consummation, and afterward had unusual opportunity to observe its effects when investigating the subject of foresting the prairie soils of Iowa. Similar destruction also occurred as the borers traversed the country between their native region and the Mississippi valley, the effects of which still remain there.

The question now arises whether there is any known remedy for the attacks of those insects. Unfortunately no effective remedy of general applicability has yet been discovered. The attacks of the insects are not upon any of the parts concerned in reproduction, such as might interfere with the propagation of the tree, but upon its growing substance, which is constantly exposed at all seasons of insect activity. Therefore its inflorescence and fruitage need no protection, and proposed remedies must be applied to the surfaces of the tree and directed against some important function in the life of the insect, mainly that of reproduction. The killing of the insects in any considerable numbers seems to be quite impracticable. The few remedies which have been proposed are fluid applications which are harmless to the trees and so repugnant to the insects that they will not puncture any surface to deposit their eggs which has been so covered. But many difficulties attend the application of such remedies. The leaves and terminal portion of the twigs are doubtless too delicate for such treatment, but the bark is not easily injured by it. The application with a brush to the bark of the trunk and branches of lime whitewash mixed with a solution of whale-oil soap has seemed to prevent the female of the borer in the beetle stage from puncturing the bark to deposit her eggs. But to be effective all such applications must carefully be made to the entire surface of the trunk and to that of the branches which have reached a couple of inches or more in diameter. They must be applied not later than midsummer, that is, before the newly matured beetles have begun the function of reproduction, and they must be continued intact until frosts have killed the last of the beetles for the year. They also must be renewed annually as long as the tree stands. One might feel justified in employing such a remedy to save a few favorite trees, but it involves too much labor to be of practical value for general application.

The foregoing statements, which are assumed to be indisputable, show that the prevailing condition of the black locust tree in the land of its origin warrants the conclusion that it is fated, not to extinction, but to destruction as a profitable natural product; and that this fate is beyond the effective reach of any known general remedy. The biological aspect of this subject is one of very great interest, but this article has purposely been confined to a presentation of its economic bearings, the significance of which is too obvious to need explanation.

A CONTRIBUTION TO THE THEORY OF SCIENCE

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ONE of the few points on which the philosophy of to-day is agreed consists in the realization that the only thing that is absolutely certain and beyond doubt for every one is the content of his own consciousness; or rather not so much the content of consciousness in general as merely the content of any given moment.

This momentary content we divide into two great groups which we assign to the inner and to the outer world, respectively. If we call a single content of consciousness of any kind an experience, we refer such experiences to the external world as take place without the participation of our own will and which can not be produced by it alone. Such experiences come to us through the participation of certain parts of our body, the sense-organs; the external world, in other words, is that which reaches our consciousness through the senses.

Conversely, we refer to our internal world all the experiences which come to pass without the immediate help of our sense-apparatus. To this class belong all the experiences which we designate as 'remembering' or 'thinking.' An accurate and complete differentiation of both territories is at present not contemplated because it is not yet necessary. It is a problem which is not capable of being attacked and solved until later. For the present a general orientation in which every man may recognize the familiar facts of his own consciousness is sufficient.

Each and every experience has the property of being unique. None of us doubts that the words of the poet: 'Everything in life repeats itself,' strictly speaking, is the opposite of the truth, and that, as a matter of fact, nothing in life repeats itself. In order, however, to pronounce a judgment of this kind we must be in a position to compare different experiences with one another; and the possibility of doing so depends upon a fundamental phenomenon of our consciousness, 'memory.' By virtue of memory alone, are we able to bring different experiences into relation with one another, and thus make it possible to propound at all the question concerning their likeness or difference.

The simpler relations are to be met with among internal experiences. Any given thought, such as twice two are four, I am able to produce in my consciousness as often as I choose; and, in addition to the con-

[1] Address before the Section of Methodology, Congress of Arts and Science, St. Louis, translated by Dr. Carl. L. Alsberg.

tent of the thought, I have the further consciousness that I have already had this thought, that it is familiar to me.

Similar, though somewhat more complicated, is the phenomenon in the case of experiences in which the external world had participated. After eating an apple, I may repeat this experience in two ways. I may repeat it as an inner experience, though with diminished intensity. Another part, the sensations that formed a piece of my experience, I am unable at will to reproduce in myself; but am compelled again to eat an apple in order to have a similar experience in this respect as well. This is a complete repetition that it is not necessarily in my power to produce because it is essential that I have an apple, *i. e.*, that certain conditions belonging to the external world and independent of myself be fulfilled.

Whether in the repetition of an experience the outer world takes part or not has no influence upon the content of consciousness, called 'memory.' It follows, therefore, that the latter belongs wholly to internal experience, and that we remember an external event only through its inner constituents. The mere repetition of corresponding sense impressions is not sufficient. We may see the same individual repeatedly without recognizing him in case the accompanying inner phenomena have, through lack of interest, been so slight that their repetition does not produce this content of consciousness, 'memory.' If, however, we see him very often, the frequent repetition of the external impression finally produces the memory of the inner experience that goes with it.

Hence it follows that to call forth the reaction, 'memory,' a definite intensity of the internal experience is necessary. This threshold value may be attained either at one time by one strong impression, or by numerous repetitions of weak ones. The repetitions are the more effective, the more rapidly they follow upon one another. Hence we may conclude further that the memory value of an experience, or its power upon repetition to call forth the reaction, 'memory,' diminishes in the course of time.

Furthermore we must take into consideration the above-mentioned fact that a completely accurate reproduction of an experience never takes place. The reaction, 'memory,' must therefore be called forth when in place of complete correspondence there is merely similarity or partial correspondence. Here, too, there are gradations. Memory appears the more easily, the more completely the two experiences correspond; and *vice versa*.

If we look at these relations from a physiological point of view, we are able to say: We possess two kinds of contrivances or organs, of which one is independent of, and the other dependent upon, our will. The former are the organs of sense, the latter is the organ of thought.

Only activity of the latter forms our experiences or the content of our consciousness. The participation of the former may call forth corresponding processes in the latter, though this is not always necessary. Our sensory apparatus may be influenced without our 'noticing' it, *i. e.,* without the participation of the apparatus of thought. A particularly important reaction of the thought apparatus is 'memory,' *i. e.,* the consciousness that an experience just taking place corresponds more or less with former experiences. It is the peculiar expression by the apparatus of thought of the general physiological law that every process influences an organ in such a way that it reacts to a repetition of this process in a way different from its reaction the first time, namely, by facilitating repetition. This effect decreases in time.

Upon these conditions experience in the abstract is based and is the result of the fact that experiences are composed of a whole series of simultaneous and successive components. If, as the result of the repetition of similar experiences (for instance the sequence of day and night), we have become familiar with the interdependence of certain experiences, we no longer perceive such an experience as an entirely new one, but rather as in part familiar, so that its separate parts or phases no longer astonish us. We anticipate or expect them. From expectation to prediction is but a very short step. Thus experience enables us to prophesy the future from the past and the present.

This is the path to science which is nothing other than experience systematized, that is to say, reduced to simple and comprehensible terms. Its aim is to predict from the known part of a phenomenon the part that has remained unknown. It matters not whether we have to deal with phenomena of space or of time. Thus from a skull the scientific zoologist is able to determine the animal; that is to say, he is able to state the nature of all the other parts of the animal to which the skull belonged. In the same way an astronomer on the basis of a few observations of the position of a planet, is able to foretell its future position. He is able to do so for a future the more remote the more accurate his original observations. All such scientific predictions are limited in regard to their content and exactness. If the skull presented to the zoologist be that of a fowl, he is able to state the characteristics of fowls in general, perhaps too whether this particular fowl possessed a comb or not. He will be unable to tell its color and only within wide limits its age or its size. Both facts, the possibility of prediction and its limitations as regards content and extent, are expressions of the fundamental fact that our experiences may be similar, but are never completely identical.

These preliminary considerations need to be explained and enlarged upon in various directions. One may object to calling a fowl or a planet an experience. We call them by the most universal name—

things. However, our knowledge of fowls always begins with the experience of certain sensations of sight with which sensations of hearing and of touch may be associated. The sensations of sight, to which we will limit ourselves for the present, are by no means completely identical. According to its distance from us, we see the fowl as large or small; with changes in its position and its movements its contour is very different. As, however, we observe that these differences pass continuously into one another without exceeding certain limits, we overlook them and confine ourselves to certain other peculiarities (legs, wings, eyes, beak, comb, etc.) which remain constant and do not change. The constant properties we gather together as a 'thing': the changing ones we call the states of this thing. Among the changing ones we distinguish those which are dependent upon ourselves (*e. g.*, distance) from those upon which we ourselves have no immediate influence (*e. g.*, position and movements). The former we call the subjectively variable part of our experience, whereas we term the latter the objective variability of the thing.

To ignore the subjectively and objectively variable portion of our experiences, while we retain their constant parts, and to combine the latter into a single unity, is one of the most important operations which we base on our experiences. We term this procedure *abstraction,* and its product, the constant unit, a *concept.* Obviously this procedure contains arbitrary as well as essential parts. Quite arbitrary, or rather accidental, is the fact that according to the state of our attention, our training, nay even our whole intellectual make-up, quite different parts of any given experience reach our consciousness. We may overlook constant components and notice changing ones. But all components become of necessity objective as soon as we have noticed them. After once seeing the fowl black, it is no longer in our power to see it red. It follows that in general our knowledge of corresponding characteristics is less extensive than it might be, inasmuch as we have never noticed all that correspond. Our concept is, therefore, poorer at any given moment in components than it might be. To search for these hitherto overlooked components of a concept and to prove them a constant part of the corresponding experience is one of the never-ceasing labors of science.

The other possibility, *viz.*, that certain components which do not prove to be constant have been incorporated into a concept, also occurs and leads to another problem. These questionable components may, on the one hand, be eliminated from the concept if further experiences show that the remaining ones are contained in them; or, on the other hand, a new concept may be formed by including the constant components and eliminating the inconstant ones. Thus for a long time the white color was a part of the concept 'Swan.' When the black swans of Australia were discovered it was necessary either to eliminate the component 'white' from the concept 'swan' (as was actually done) or else to create a new concept for the bird which resembled a swan, but was black. Which course is decided upon is to a great extent arbitrary, and determined by considerations of fitness.

We have then two factors participating in the formation of a concept, one objective, the result of experience; and one subjective, dictated by fitness. The fitness of a concept is adaptation to the purpose to which it is to be put, and it is this case that we must now consider.

The purpose of a concept is its application in prediction. Ancient logic established the syllogism as the type of the process of thinking, the simplest example of which is the familiar:

> All men are mortal;
> Cajus is a man;
> Therefore, Cajus is mortal.

The universal formula is:

> To the concept M belongs the component B;
> C is included in the concept M;
> Therefore the component B is found in C.

It may be said that this method of reasoning has remained in use up to the present day. We must, to be sure, add that its application is of a sort quite different from its ancient one. While formerly propounding the major premise was considered the more important, and the propounding of the minor premises was regarded as an almost self-evident and easy matter, to-day the relations have been reversed. The major premise contains the description of a concept, the minor makes the assertion that a certain thing must be classed under this concept. What justification is there for such an assertion?

The most evident answer is that because all the components of the concept M (including B) are to be found in C, C must be classed under the concept M. A conclusion of this kind would certainly be true, but at the same time quite valueless, for it only repeats the assertion of the minor premise.

As a matter of fact, our method of drawing conclusions is essentially different, for the minor premise is not obtained by proving all the constituents of the concept M to be present in C; but only some of them. The conclusion is, therefore, not binding, but merely probable. The whole method of drawing a conclusion is as follows: Certain constituents frequently occur together. They are combined to form the concept M. In the thing C some of the constituents may be recognized. Therefore, presumably the other components of the concept M occur in C.

Ancient logic was also familiar with this method of reasoning; but it was branded with the name of incomplete induction as the worst of all because it lacks absolute and unconditional certainty. One must admit, however, that all contemporary science makes use of no form of reasoning other than incomplete induction. It alone permits of prediction, that is to say, the determination of relations which have not yet been directly observed.

But how does science get along with this lack of certainty in its method of drawing conclusions? The reply to this question is that the probability of the conclusions may run the gamut of all possible gradations from mere supposition to the maximum of probability which is no longer to be distinguished, practically, from certainty. The probability is greater the more frequently any given incomplete induction of this kind has been found consistent with subsequent experience. Thus we have at our disposal a number of propositions which in their simplest and most general shape take the form: If the component A is to be found in a given thing, the component B is also to be found in it (in relation to either time or space).

If the relation is one of time, we term this general proposition the law of causality. If it is one of space we speak of the idea (in the Platonic sense) or type of the thing, of substance, etc.

These considerations yield answers to many questions which have been repeatedly propounded in various forms. We have first the question of the universal validity of the law of causality. All attempts to establish this kind of validity have failed, and only the fact remains that without this law we should feel an unendurable uncertainty as to the world. Hence it follows that we have to deal in this matter with a question of fitness. From the constant stream of our experience we select relations which we encounter again and again in order that whenever the component A is given us we may conclude that the component B is also to be found. Hence we do not find these correlations occurring as 'given,' but we ourselves bring them into our experiences, by ourselves regarding the components which show such a connection as belonging together.

We may make quite the same statements in regard to space relations. The components which are always, or at any rate frequently, encountered together we interpret as forming a unit; and we shape from them a concept which includes these components. As in the case of time relation, there is no sense in propounding the question *why*. There are thousands of correlations to which we pay no attention because they are unique or rare. Knowledge of such a unique correlation leads to nothing, because it does not enable us to infer the presence of one component from the presence of another and therefore does not render prediction possible. Of all possible and actual combinations only those interest us which are repeated. This arbitrary though fit selection creates the impression that these are the only recurring combinations, or that, in other words, the law of casuality or of type rules unqualifiedly. How universal or how limited is the application of these laws is therefore rather a question of our skill in selecting the constant combinations from among all those occurring than a question of objective natural phenomena.

Thus we observe the development and practise of all sciences progressing in this manner by the discovery, on the one hand, of ever more numerous individual constant combinations, and, on the other, of more and more universal laws by means of which components are brought into relation with one another, which formerly no one had attempted to bring together. Thus sciences grow in that they become *complex* and at the same time *unified*.

If now we consider the development and course of the various sciences from this point of view we shall attain a rational classification of all science by an inquiry into the extent and complexity of the combinations or complexes which they treat. Both characteristics are in a sense antagonistic. The simpler a complex is, that is, the fewer the components united in it, the more frequently will it occur; and *vice versa*. It will therefore be possible to classify all the sciences in this fashion by beginning with the minimum of complexity and the maximum of extent and ending with the maximum of complexity and the minimum of extent. The first science will include the most general and therefore the poorest and most meager concepts; the last the most specialized and therefore the richest.

What then are these limiting concepts? The most universal is the thing, any fraction of experience arbitrarily selected from the stream of our experiences and capable of repetition. The most specialized and the richest is the concept of human society. Between the study of things and the study of human society all the remaining sciences may be interpolated in an orderly series. The attempt to follow out this scheme leads to the following table:

1. Science of manifoldness or assemblages, Logic.

$$\left.\begin{array}{l}\text{2. Science of numbers or arithmetic,}\\\text{3. Science of time,}\\\text{4. Science of space or geometry,}\end{array}\right\}\text{Mathematics.}$$

$$\left.\begin{array}{l}\text{5. Mechanics,}\\\text{6. Physics,}\\\text{7. Chemistry,}\end{array}\right\}\text{Energetics.}$$

$$\left.\begin{array}{l}\text{8. Physiology,}\\\text{9. Psychology,}\\\text{10. Sociology,}\end{array}\right\}\text{Biology.}$$

This table contains an arbitrary element inasmuch as the steps assumed in it may be multiplied. Thus mechanics and physics might be combined or physical chemistry interpolated between physics and chemistry. Similarly anthropology might be placed between physiology and psychology while the first four sciences might be combined as mathematics. How this subdivision is to be carried out is purely a practical question which will be answered differently by different ages and concerning which it is useless to quarrel.

I would like, however, to call attention to the three great divisions: Mathematics, energetics and biology (in the broader sense). They represent the three guiding thoughts which up to the present mankind has brought forth for the purpose of mastering scientifically its experiences. *Order* is the fundamental thought of mathematics, *energy* the guiding concept from mechanics to chemistry; for the last three sciences it is *life*. Mathematics, energetics and biology therefore embrace the whole body of the sciences, while logic precedes them all.

Before entering upon a more detailed consideration of these sciences, it is well to anticipate an objection which may be raised on the basis of the following fact. There are in addition to the previously mentioned sciences (as well as the intermediate ones) many others such as geology, history, medicine, philology, which present difficulties if a place is sought for them in our scheme, and which, nevertheless, demand consideration. It is often characteristic of them that they bear relation to several of the sciences which have been enumerated; and still more characteristic of them is it that they do not search for universal relations as do the pure sciences, but rather treat existing complex objects in order to 'explain' or discover their origin, extent, distribution, in a word their time and space relations. To accomplish this object they make use of the relations which the pure sciences have put at their disposal. It is best to designate these sciences as *applied* sciences. This term is not meant to imply either exclusively or even chiefly technical application. It is merely intended to express the fact that here interrelations of the parts of a ready-made object are rendered intelligible by the application of the general laws which have been discovered by pure science.

In a problem of this nature it is usually necessary to make use of several different pure sciences simultaneously for an explanation, because the abstract method of the pure sciences is not permissible here. To omit certain parts and to limit oneself to certain others is from the very nature of the problem out of the question. Astronomy is an applied science of this sort. It is based immediately upon mechanics; in its instrumental part upon optics; while in its contemporaneous spectroscopic development it borrows much from chemistry. Thus history is applied sociology and psychology; medicine makes use of all preceding sciences up to psychology, etc.

It is important to realize the nature of these applied sciences since their composite nature renders it impossible to classify them among the pure sciences, though, because of their practical importance, they demand consideration. The latter characteristic gives them to a certain extent an arbitrary or accidental character since their development depends upon the particular requirements of the times. Their number, broadly speaking, is very great because every pure science may be changed to an applied one in many ways and may be combined for this purpose with one or more other sciences. Furthermore, the method of applied science is fundamentally different from that of pure science inasmuch as the former seeks to analyze any given complex into its scientifically manageable parts, whereas conversely the latter considers many complexes in order to extract from them their common feature and explicitly refrains from the complete analysis of each individual complex.

In scientific work, as carried out in practise, pure and applied science are by no means always to be sharply separated. On the one hand, the means of research, apparatus, books, etc., demand the knowledge and the practise of applied science even by the 'pure' investigator. On the other hand, the 'applied' investigator is often able to solve his problem only by becoming temporarily a 'pure' investigator and himself ferreting out or discovering the universal relations which he needs for the solution of his problem. The separation and differentiation of these two kinds of science was, however, necessary, because each employs quite different methods and pursues essentially different ends.

In order that we may attain a clear understanding of the method of pure science, we will turn to the table on page 225 and consider the individual sciences separately. The first place is ordinarily given to mathematics as to the science of quantity. However, mathematics deals with number and size as its fundamental concepts, while the science of assemblages does not as yet use them. Moreover, in the latter, the fundamental concept is the thing or object of which no more is required than merely that it be a fraction of our experience capable of being isolated and remaining so. It may not be any indiscriminate fraction, for such a one could have but a momentary duration; and the aim of science, to discover the unknown from what is given, could not be accomplished with it. This part of experience must rather be of such a nature that it may be distinguished and recognized, that is to say, it must already be of the nature of a concept. Only those parts of our experience which are capable of repetition (for these alone can form the subject-matter of science) can be called things or objects. This statement, however, includes everything that is required of them. Otherwise they may differ as much as is conceivable.

If it be asked what scientific statements it is possible to make concerning such uncertain things, one will find that the relations of order and classification are the ones to yield results. If we designate any limited combination of things of this nature a group, we may arrange a group in different ways, that is, we may determine for each thing the relation in which it is to stand toward neighboring things. Such an arrangement produces not merely the relations prescribed above, but in addition a large number of new ones; and it becomes plain that, given the first relations, the others may be observed at once. This gives us the type of a law of nature: the possibility of inferring from the presence of a definite classification-relation the presence of others which we have not yet tested.

To illustrate by an example: Let us imagine the things arranged in a simple series formed by choosing one thing for the first member; placing another next to this one; then a new one next to the latter; another next to the last, etc. The position of each thing in the series is determined in relation to the immediately preceding one. Nevertheless the position of every member of the entire series is determined; and thus its relation to every other member. This fact appears in a number of special laws. If we distinguish between preceding and succeeding members one of the laws we may observe is: If B is a succeeding member in relation to A, and if C is a succeeding member in relation to B, then C is also a succeeding member in relation to A.

The correctness and universal validity of this proposition seems to us beyond any possible doubt. It depends, however, merely upon the fact that we are able to test it with the greatest ease in innumerable individual instances and have so tested it. We know none other than instances agreeing with this proposition and none that contradict. Therefore, to designate such a statement as a necessity of thought seems to me misleading. Now the expression necessity of thought can only be based upon the fact that each time one thinks this proposition, that is, remembers having tested it, one always has in mind its confirmation. Any wrong proposition is, however, conceivable as the fact that so much that is wrong is actually thought indisputably shows. To base the proof of the truth of a proposition upon the inconceivability of its converse is an undertaking that can not be carried out, because it is possible to think any sort of nonsense. Whenever this proof was believed to have been demonstrated, thinking was always confused with considering, demonstrating or proving.

Of course the theory of groups is not exhausted with this single statement. We do not, however, care to develop this theory here, but rather to give an example of the nature of the problems of science. Of the other questions only the method of coordination will be briefly treated.

Given two quantities A and B, one may assign to every member of A a member of B, that is, one determines that certain operations which are to be carried out with the members of *A*, shall also be carried out with those of *B*. We may begin by simply associating them member for member. Then one of three things will happen: either *A* will be exhausted while members of *B* remain, or *B* is first exhausted, or finally *A* and *B* are exhausted simultaneously. In the first case we say that *A* is poorer than *B*; in the second *B* is poorer than *A*; and in the third case that both quantities are equal.

We meet now for the first time the scientific concept of equality; and it is necessary that we enlarge upon it. Absolutely complete identity of both groups is obviously out of the question, inasmuch as we made the assumption that the members of both groups might be of any nature whatsoever. Regarded singly they may be as different as possible. They are, however, equal as groups. For, however I arrange the members of *A*, inasmuch as a member of *B* is assigned to every member of *A*, I am able to carry out every arrangement of *A* upon *B* as well. As regards the possibilities of arrangement there is no apparent difference between *A* and *B*. As soon, however, as *A* is either poorer or richer than *B*, this similarity disappears, for one of the two quantities possesses members to which no members of the other groups correspond. The operations that may be performed upon these members can not be carried out upon the second group.

Equality, in the scientific sense of the word, signifies, therefore, equivalence or the possibility of substitution as regards definite operations or relations. In all other respects the things that have been pronounced equal may differ in any way. It is easy in this special case to recognize the universal method of abstraction of science.

It is possible on the basis of these definitions to make further propositions. If the quantity *A* is equal to *B* and if *B* is equal to *C*, then *A* is also equal to *C*. This may be proved by first arranging *A* with reference to *B*. According to our presupposition no member remains. Thereupon *C* is arranged with reference to *B* with no member remaining. In this way every member of *A* is, through the intervention of *B*, assigned to a member of *C*. Moreover, this arrangement remains unchanged even after the removal of *B*, *i. e.*, *A* and *C* are equal. The same method may be applied to any number of quantities.

It is possible to prove in a similar manner that, if *A* is poorer than *B*, and *B* is poorer than *C*, *A* must also be poorer than *C*. For in assigning the members of *B* to *A*, some members of *B* will, according to our assumption, remain, and the same will be true of *C* if we assign the members of *C* to those of *B*. Hence in assigning the members of *C* to those of *A* there are left not merely the members which can not be assigned to *B*, but also the members of *C* which have been assigned to such members of *B* as are supernumerary in respect to *A*. This proposition is applicable to all groups and renders it possible to arrange different groups in a series by beginning with the poorest and choosing each succeeding one so that it is richer than its predecessor though poorer than its successor. Through a proposition that has been already proved (p. 229) it follows that each group is thus also arranged with reference to all other groups in such a way that it is richer than all its predecessors as well as poorer than all its successors.[2]

In developing most simple propositions or laws, this method of their discovery and the nature of the results become most clear to us. We achieve such a proposition by carrying out an operation and giving expression to its results. This expression enables us thereafter to save ourselves the trouble of repeating the operation. We are able to give the result immediately in accordance with the law. Thus we shorten and facilitate the procedure more or less according to the number of operations avoided.

Given any number of equal groups, we recognize that by arranging them with relation to one another as above, we are able to carry out upon all of them each and every operation involving arrangement that we are able to carry out upon one of them. It is therefore sufficient to determine the characteristics of arrangement of any one of these groups in order to know those of all the others. This is a most important proposition which is constantly applied for manifold purposes. Thus talking, writing and reading are founded upon the coordinating of thoughts to sounds and signs; and by arranging the signs in accordance with our thoughts we cause our hearers or our readers to think the same thoughts in the same sequence. We manipulate many formulæ in a similar manner (especially in the simpler sciences), applying the results to phenomena, instead of dealing with the phenomena themselves; and we are able to deduce some properties of the latter without being compelled to work with the phenomena themselves. The force of this procedure is most striking in astronomy, where, by manipulating certain formulæ which have been applied to certain celestial bodies, we are able to predict their future positions with a great degree of accuracy.

From the science of order we pass to the science of numbers or arithmetic by the systematic development of an operation that has just been indicated. We are able to arrange any given number of quantities in such a manner that the richer always succeeds the poorer. The system obtained in this fashion is, however, quite accidental as regards the number and richness of its members. Obviously we can only obtain an orderly structure of all possible groups by starting with a group having but one member, *i. e.*, a simple thing, and forming new members of the series from old ones by adding a single member. By this process we at once obtain the different groups arranged

[2] Equal groups can not be distinguished here; and represent merely a single quantity.

according to their richness. Further, inasmuch as we advanced by a single member, that is, we have made the smallest step possible, we are certain to have omitted no possible group that is poorer than the richest to which we have advanced our operation.

This whole procedure is well known. It yields the entire series of positive numbers—the cardinal numbers. It is to be noted that the concept of magnitude does not appear as yet. What we have obtained is merely the concept of number. The individual members may be chosen quite arbitrarily. They need in no way be equal. Each number represents a quantity type; and it is the sphere of arithmetic to examine these different types in respect to subdivision and combination. If this be done without considering the amount of the number, we call the corresponding science algebra. On the other hand, the extension of formal rules beyond their original application has led to one development of numbers after the other. Thus counting backwards leads to zero and the negative numbers, the square root of the latter to the imaginary numbers. The quantity-type of all the positive numbers is, to be sure, the simplest, though by no means the only possible one. For the purpose of representing other arrangements such as occur among our experiences these new types have proved very useful.

At the same time the numerical series yields a most useful type of arrangement. From its very origin it is arranged in an orderly fashion and it is therefore employed for the purpose of arranging other quantities. Thus we are accustomed to apply the signs of the numerical series to any objects which we desire to use in a definite order, such as the pages of a book, the seats in a theater, as well as countless other groups. We, however, tacitly make the assumption that the arranged groups are to be used in the same sequence in which the natural numbers follow one another. These sequence-numbers represent no magnitudes nor do they represent the only type of arrangement possible. They are, however, the very simplest.

We do not reach the concept of magnitude until we reach the science of time and space. A science of time has not been developed separately. On the contrary, what there is to say about time usually appears for the first time in mechanics. However, it is possible for us to state the fundamental characteristics of time here, so that the want of a distinct science of time will not be felt.

The first and most important property of time (and also of space) is that it is continuous. In other words, any portion of time may be divided at any point. In the numerical series this is not the case; it may be divided only between numbers. The series one to ten has nine places of division, and only nine. A minute or a second, on the other hand, has an unlimited number of possible points of division. In other words, there is nothing in the passage of time preventing us at any desired moment from separating or distinguishing in thought the time that has passed from that which is to follow. Space is of the same nature, except that time is simple, space threefold.

Nevertheless, we are accustomed to describe both time and space by means of numbers whenever we measure them. If we examine into this procedure, for instance in the case of measuring length, we find that it consists in applying a length considered fixed, the measure, as often to the length to be measured as is necessary to cover it. The number of applications gives us the measure or magnitude of the length. It merely amounts to forcing an artificial discontinuity upon a continuous length by marking off arbitrarily chosen points, allowing us to refer it to the discontinuous numerical series.

The equality of the portions of distance set off by the measuring-rod is an essential part of the concept of measuring. We assume this condition fulfilled no matter how the measuring-rod be shifted. As we see, this is a more forced definition of equality than heretofore made, for it is actually quite impossible to substitute a given portion of a distance for another in order to become convinced that the validity of our definition is not impaired, that nothing is changed thereby. It is quite as impossible to prove that the measuring-rod in being shifted in space remains of the same length. We may only affirm that such distances as are determined in various places by means of the measuring-rod are declared or defined as equal. As a matter of fact, the measuring-rod in perspective looks smaller the further it is away from us.

This example demonstrates anew the great arbitrariness with which we shape science. It is conceivable that a geometry might be developed in which the distances are considered equal which subjectively appear to our eye to be so, and we should then be quite as able to develop a consistent system or science. A geometry of this kind would, however, be of too complicated a nature to be advantageous for any objective purpose (*e. g.*, surveying). Therefore we endeavor to develop a science as free as possible from subjective factors. Historically the Ptolemaic astronomy and that of Copernicus present an illustration in point. The former was formed according to subjective appearances in its assumption that the stars revolved about the earth. It proved most complicated when confronted with the problem of expressing these motions mathematically. The latter gave up the subjective point of view of the observer who regarded himself as the center; and, by transferring the center of motion to the sun, produced an enormous simplification.

A few more words are necessary at this point concerning the application of arithmetic and algebra in geometry. It is well known that under certain assumptions (coordinates) geometric figures may be expressed in algebraic formulæ so that it is possible to deduce the geometric properties of the figures from the calculatory properties of the formulæ, and *vice versa*. We must inquire how such close and unambiguous relations can exist between things so diverse. The answer is that we have to deal in this instance with a particularly obvious case of association. The manifoldness of numbers is far greater than that of planes or space, for, whereas the latter are determined by but two or three independent measurements, any number of independent numerical series may be made to react upon one another. We therefore arbitrarily limit the manifoldness of the numbers to two or three independent series, and determine (by means of the cosinus law) their mutual relations so that a manifoldness corresponding exactly to that of the space arises to which we are able completely to refer it. We have then two manifoldnesses of identical character; and all properties of arrangement and size of the one are 'depicted' in the other. In this an extremely important scientific procedure is indicated which consists in giving to the experience-content of a given field a formal manifoldness to which we impart the same manifoldness-character as that possessed by the former. Every science thus develops a formula language of its own, perfect in proportion to the accuracy with which the manifoldness-character of the object has been recognized, and the fitness of the formulæ selected. Whereas, in arithmetic and algebra this problem has been solved quite perfectly (though by no means absolutely so), chemical formulæ, for instance, express only a relatively small part of the characteristics which they ought to express, while in biology and sociology we have hardly progressed beyond the very beginnings of the solution of this problem.

One of these universal manifoldnesses designed to express our experiences is speech. Inasmuch as it was developed in a primitive civilization it is by no means regular and complete enough to fulfil its purpose satisfactorily. On the contrary, it is quite as unsystematic as were the events in the history of the various peoples. The need to express the infinite variety of events in daily life has been filled by allowing word and concept to correspond only within a wide limit of variation. Therefore all research in the sciences which are forced to employ this means of expression (psychology and sociology or philosophy generally) is greatly impeded by the struggle with the indefiniteness and ambiguity of language. An improvement of these conditions is to be attained only by the introduction, as rapidly as the progress of the science warrants it, of symbols to which we refer the manifoldness which experience tells us is peculiar to the concept.

The sciences which have been classed above as a part of energetics occupy an intermediate position. In addition to the concepts of order, number, magnitude, space and time we meet in this branch of knowledge with the new concept of energy, which is applied as universally to every phenomenon in this field as the other universal concepts. This is so because a certain magnitude, known to us immediately as mechanical work, may be proved to be a constituent of every physical phenomenon, *i. e.,* of mechanics, physics and chemistry, by virtue of its qualitative transformability, and its quantitative immutability. In other words, it is possible to characterize every physical phenomenon completely by stating what quantities and kinds of energy are present and into what kinds of energy they are transformed. It is, therefore, more rational to term the so-called physical phenomena, energetic.

That such a conception is possible is now generally acknowledged, but its utility is usually doubted. These doubts are at present justified, inasmuch as a complete exposition of the physical sciences from the point of view of energetics has not been thoroughly carried out. If the above-mentioned criterion of a scientific system, *viz.,* the conformity of the representing manifoldness to the one depicted, be applied to this question, we shall find unmistakably that all previous systematizations, which in the form of hypotheses have been attempted in these sciences, are faulty in this respect. Hitherto manifoldnesses have been used for the purpose of 'depicting' experiences the character of which corresponded to the depicted object only in a few main points. No attention was paid to the necessity of exact correspondence. There was no concise formulation or investigation of this side of the problem.

Now the energetic point of view permits as great a certainty in the method of depiction or expression as is necessary or possible for the state of the science at the time. For the manifoldness-character of each department there is a special form of energy. Thus science has long since distinguished between mechanical, electrical, thermal, chemical and other forms of energy. All these different varieties are related through the law of transformation with the conservation of energy. They are therefore organically connected. On the other hand, it has been possible to find the energetic expression for every manifoldness as yet discovered empirically. The future system of energetics in its entirety will therefore be a table of all the possible manifoldnesses of which energy is capable. It must be noted, however, that as a consequence of the law of the conservation of energy, energy is of necessity a positive magnitude which furthermore is without limit additive. Each special kind of energy must therefore also have this character.

The very slight degree of manifoldness which these conditions seem to leave us is increased very much by the fact that every form of energy may be resolved into two factors. The latter are subject to but a single limitation, *viz.,* that their product, energy, fulfils the above conditions, while they themselves are far more free. Thus, one of the factors of a form of energy may become negative instead of positive, if the other factor also becomes negative.

Accordingly it would seem possible to construct a table of all the possible forms of energy by assigning to the factors of energy all possible manifoldness characteristics and combining them in pairs, with the subsequent elimination of the products which do not conform to the conditions stated on p. 234. By comparison with all the forms of energy known at the time, it would be possible to discover the forms that were still unknown and to outline their most important properties. Experience would merely have to discover their specific constants. For some years I have myself from time to time attempted to carry out this program; but hitherto I have not progressed far enough to justify the publication of the results already obtained.

If now we turn to the biological sciences, the new phenomenon we meet is *life*. If we limit ourselves to observable facts excluding all hypotheses, we shall recognize as the universal characteristic of all life-phenomena the stationary stream of energy which flows through a comparatively constant structure. Metabolism is merely a part, though a most important part, of this stream. Plants, particularly, demonstrate immediately the paramount importance of energy in its most immaterial form, the sunbeams. Self-maintenance and repair with the production of similar descendants are other essential characteristics. All these characteristics must be present in order that an organism may arise. Furthermore they must be present if the knowing individual is to be capable of forming, by repeated experiences, a concept of any given organism, say a lion or a mold. Other organisms not fulfilling these conditions may occur. Because they are unique, they do not lead to the concept of a species, but are excluded (except of course for special purposes) from scientific consideration as 'malformations' or 'monsters.'

Whereas organisms mostly deal with forms of energy which are familiar to us in the inorganic world, we find the higher forms possessed of organs which undoubtedly produce, or are active in, the transformation of energy, though we do not know which form of energy acts within them. These organs are termed nerves; and their functioning is regularly of such a nature that upon the application of a definite form of energy to one end, they call into action at the other end forms of energy there present and which there act in their own peculiarly characteristic way. That energetic changes do occur in the process of nerve-transmission may be regarded as settled. We are therefore justified in speaking of nerve energy, leaving the question open as to whether it be a special form of energy or merely chemical energy or lastly a combination of several forms of energy.

While these processes of nerve stimulation with corresponding reaction in the end-organ, a muscle, for example, may be observed objectively, we find within ourselves connected with this nervous process a new kind of phenomenon which we term self-consciousness. From the correspondence of our reactions with those of other people we conclude with scientific probability that they too are possessed of self-consciousness. We draw the same conclusion concerning a few of the higher animals. How far down the scale anything similar is present is not to be ascertained with the means at our command to-day, for the analogy between organization and action rapidly diminishes as we pass down the scale. Still in view of the very great gulf between man and the higher animals, this series is presumably not very long. Moreover, there are many reasons for regarding the gray cortical substance of the brain with its characteristic pyramidal cells as the anatomical substratum for this kind of nervous activity.

The study of the processes of self-consciousness is the subject-matter of psychology. Some departments usually considered a part of philosophy really belong to this science, *viz.,* the theory of knowledge. Esthetics, and still more ethics, are, however, a part of social science.

The latter deals with beings in so far as they may be combined in groups with common functions. In place of an individual mind we have here a collective one. The latter, by virtue of the average struck between the variations of the individuals, presents simpler relations than the former. Thence we may deduce the problem of the historical sciences. The events of our world depend partly upon physical, partly upon psychological factors. Both show a one-sidedness in regard to time. Thus arises, on the one hand, a history of the sky and the earth; and, on the other, a history of the organisms up to man.

The problem of history is to fix past facts through the effects they have wrought. Where the latter are not present we are dependent for a conception of the facts upon that most uncertain procedure, analogy. We must observe, however, that an event which has left no trail has absolutely no interest for us. Our interest in an event is directly proportional to the extent of the change it has produced upon the present. The problem of history is, however, as little exhausted by determining past facts as is that of physics by ascertaining an isolated fact, such as determining the temperature of a given place at a given time. The individual facts serve rather to discover the general properties of the collective mind; and the much-discussed laws of history are laws of collective psychology. Just as physical and chemical laws are discovered in order that with their help we may predict future events (such as those produced in experiment or technology), so laws of history should render possible the control and the development of society and of politics. We observe that the great statesmen of all times assiduously studied history; and hence we may conclude that, despite the doubts expressed by many scholars, numerous laws actually exist in history.

If after this cursory survey we review the ground we have covered, we shall recognize the following general relations: In each case the development of a science consists in correlating concepts formed from definite abstractions derived from experience; and by this means we achieve in our minds a mastery over certain parts of our experiences. Such correlations are termed according to the degree of their universality and reliability, rules or laws. A law is the more important, the more definite its statement concerning the greatest possible number of things; and the more accurately it consequently permits of predicting the future. Every law is based upon incomplete induction and is therefore liable to modification by experience. Hence the development of science is of necessity twofold.

In the first place actual relations are examined to see whether or not new relations other than those already known may not be discovered, *i. e.*, constant relations between individual peculiarities. This is the inductive method. And because the possibilities of experience are unlimited it must ever be an incomplete method.

In the second place, relations discovered by induction are applied to cases which have not yet been investigated. Cases resulting from the combination of several inductive laws are particularly liable to be studied. If the combination is correctly made and if the inductive laws are absolutely certain, the result has a claim to unconditional validity. This is the limiting case which all sciences strive to approach. It is almost attained by the simplest sciences, mathematics and certain parts of mechanics. This is termed the deductive method.

In the actual practise of every science both methods of investigation constantly alternate. The best method to discover new and significant inductions is to make a deduction even though its basis be insufficient, requiring subsequent proof from experience. Sometimes the investigator is not conscious of the separate steps of his deduction. In such cases scientific instinct is spoken of. On the other hand, great mathematicians have informed us that they used to find their general laws by induction, by trying and considering individual cases, and that their deductive derivation from other known laws is an independent operation which at times did not follow until much later. Even to-day there are a number of mathematical propositions which have not reached the second stage and which are therefore at present of a purely inductive and empirical character. The part that such laws play in the sciences rapidly increases as we pass up the series.

Another peculiarity which may be mentioned here is that in the series all preceding sciences assume the characteristics of applied sciences in respect to succeeding ones because they are essential to the course of the last without being themselves increased. They are merely helps to the latter.

If, in conclusion, we ask what influence investigations such as have just been sketched in outline can have upon the development of the future the following may be said: Whether a great and influential man of science develop and where, has hitherto been regarded as an event quite beyond control. All are agreed that such a one is one of the most precious treasures a nation (or indeed mankind) may possess. The conscious and regular training of such rarities had not been considered possible. While this is still true in the case of the quite exceptional genius, nevertheless countries of old civilization, at present notably Germany, exhibit an educational system at their universities which yields a regular harvest of young men of science, masters not merely of existing knowledge, but also of the technique of discovery. In this fashion the growth of science has been rendered sure and regular while its practise has been raised to a higher plane. These results have hitherto been attained by essentially empirical or even accidental means. It is the problem of the philosophy of science to regulate and systematize this activity in order that success may no longer depend solely upon individual talent, but may also be achieved by less original minds. Mastery of method, moreover, leads the exceptionally gifted individual to considerably higher achievements than he could attain without it.

THE JEWSHARP

By the late Dr. H. Carrington Bolton

THE common English name of this primitive musical instrument is misleading, for it is not a harp nor has it any associations with Hebrews, as its appellation seems to imply. That it has nothing to do with Jews as respects either its origin or its employment is easier to demonstrate than it is to determine the real significance of its name, or the occasion of its invention. Antiquarians and lexicographers have attempted to trace the history and etymology of this term, but their suggestions are for the most part mere guesses.

Samuel Pegge, an antiquary of the eighteenth century, derives jewsharp from 'jaw's harp,' which is regarded by later authorities as absurd; and Skeat in his useful 'Etymological Dictionary' takes the singular view that this name was 'given in derision, probably with reference to the harp of David.' Dr. Littleton, adopting the vulgar error that the instrument is Jewish, inserted in his Latin Dictionary (1679), the phrase 'Sistrum Judaicum,' a mere translation, notwithstanding the fact that the term *Crembalum* had been used sixty years before by Praetorius in his 'Organographia.' After all, the simple proposition of another writer is not so improbable as it might seem; he suggests that, after a long interval of disuse and of forgotten name, the instrument was peddled through England and Scotland by a Jew, and the name jewsharp became naturally the popular one.

Another distinctive name current prior to the nineteenth century was 'trump,' or 'jews' trump,' prevalent especially in Scotland. The earliest mention of this musical instrument known to the writer has the latter form; in Sir Richard Holland's 'Duke of Howlat,' a Scottish poem satirizing King James, occurs a long list of musical instruments, from which we take a single line:

> The trump, and the talburn, the tympane but tray.
> (Line 760.)

This poem dates from the middle of the fifteenth century. The word trump is almost identical with the French 'trompe' applied to the jewsharp, as well as to several other musical instruments, the trumpet, the horn and even the rattle. Another common name in French is 'guimbarde'; in German the term is 'Maultrommel,' and 'Brummeisen'; in Italian it is known by the poetical expression, 'Scaccia pensieri,' banisher of thought. The word trump prevailed in Scotland, as was natural, considering the intimacy with France, and the phrase jews' trump was used by English dramatists until the end of the seventeenth century. Henrie Chettle, in the poem 'Kind Hearts' Dream,' dated 1592, wrote: "There is another juggler that being well skilled in the Jews' Trump takes upon him to be dealer in musick." In the following century Thomas Randolph wrote:

> O, let me hear some silent song
> Tun'd by the Jews' trump of they tongue.
> (The Conceited Peddler.)

About fifty years later Thomas Otway in his 'Friendship in Fashion' represents one of the actors, 'Malagene,' pulling out a Jews' trump and playing a tune. (1685.) Some wiseacre, seeking the derivation of Jews' trump, makes the suggestion that it is a corruption of *jeu-de-trompe,* but the guess loses much force owing to the simple fact that this expression does not occur in French.

In 'Hakluyt's Voyages'[1] the instrument is called simply 'Jewes-harpe.' The early explorers found these toys very advantageous as articles for trading with the aborigines; the barter of 'hatchets, knives and jews-harps' is mentioned by R. Duddeley, in 1595, and one year later Sir Walter Raleigh wrote of the same people: 'Wee should send them Jewes-Harpes, for they would give for every one two Hennes.'

These baubles were also acceptable to the natives of Guiana in South America; R. Harcourt names them in connection with beads and knives. This trade with the aborigines of the western continent has continued until modern times; Mr. Joseph D. McGuire refers to it in connection with his description of a pipe of catlinite carved in form of a jewsharp.[2]

In Bailey's Dictionary, which dates from the eighteenth century, the term is jewstrump, and in Teesdale's 'Glossary' still another synonym is used, 'gew-gaw'; this last name is also used for a kind of flute in Scotland.

This humble instrument of music, treasured chiefly by semi-civilized races and by children of intellectual nations, is but rarely mentioned in print, as its mediocre qualities give it no prominence in musical circles, and toys are seldom subjects of discussion. Sir Thomas Brown states that a brass jewsharp richly gilded was found in an ancient Norwegian urn; this suggests great antiquity, a point which will be discussed later.

In the report of those horrible witch trials conducted in the reign of James VI. of Scotland, in 1591, the 'grave and matron-like' Agnes Sampson and the poor servant Gellie Duncan play conspicuous and melancholy parts. After horrible tortures, Agnes confessed that Gellie, Dr. Fian and herself, with upwards of two hundred witches, used to assemble at midnight in a kirk, where they were joined by the devil himself, who incited them to murder the king. On these occasions the devil always liked to have a little music, and Gellie Duncan used to play a reel on a trump, or jewsharp, while all the witches danced. And at another time when a large number of witches marched in procession

[1] 'Hakluyt's Voyages,' III., 576.
[2] Report National Museum. 1897, p. 488.

to hear the devil a-preaching, Gellie Duncan, the musician of the party, tripped on before, playing on her jewsharp and singing:

> Cummer, go ye before, cummer go ye;
> Gif ye will not go before, cummer, let me.

The Skene manuscript of Scottish melodies, written about the years 1615 to 1620, mentions the trump, and William Daunay commenting on this says the jewsharp was the only instrument of music formerly known to the inhabitants of St. Kilda; and as this isolated, rocky island had only twenty-seven families residing there in 1793, Daunay's statement seems credible.

These few notes and the references scattered through that rich treasury for antiquarians, the English 'Notes and Queries,' are evidently written by persons ignorant of the birthplace and great antiquity of the jewsharp; examination of the collection in the U. S. National Museum, however, shows that Asia can indubitably claim that distinction, for the primitive models preserved there prove that these musical instruments are widely known throughout the Orient. They are common in the Chinese empire, Thibet, Burmah, Siam, and Japan, as well as in the islands of Borneo, New Guinea, Sumatra, Samoa, Fiji and the Philippines. The Chinese call the jewsharp *Keou Kin,* 'mouth harp,' and consider it very ancient, and with some reason, for it is found among the Ainos, the original inhabitants of Japan, of whom a few survive in the northern islands.

As constructed by orientals who have not been influenced by contact with Europeans and Americans, their jewsharps are made of narrow pieces of bamboo from five to nine inches in length, and split so as to form a longitudinal section in which the jaws and tongue are cut somewhat like a three-pronged fork. A portion of the bamboo, of full size, is sometimes left attached to the split section to serve as a handle, and this measures in addition five to seven inches in length.

Often the construction is peculiar in that the jaws of the instrument are made to vibrate instead of the tongue, in which case the tongue occupies an inverse position. In jewsharps made by the Ainos the vibration of the tongue is effected by a bit of bamboo fiber fastened to a minute orifice at its base. These wooden jewsharps have little power, and the modern Chinese, imitating Europeans, make them of iron with a projecting handle, which is virtually a prolongation of the tongue beyond the point where it is riveted to the jaws.

Several native tribes in the Philippines make jewsharps—the Moros, on northern Mindanao, the inhabitants of the Sooloo archipelago and the Negritos. In Burmah and Thibet, where the common name is Murchang (or simply Chang), they are not made by the Thibetans themselves, but by the Lissus and by tribes in the southeastern districts, where nearly all women carry jewsharps in ornamental cases suspended from their girdles. Melodies are played on three having a different pitch.

For the opportunity of examining the collection in the National Museum and information concerning them I am indebted to Professor Otis T. Mason, acting curator in anthropology, and to Mr. E. H. Hawley, preparator in charge of musical instruments.

The Waschamba tribe in Africa make a childish toy used like a jewsharp, quite unique in construction. Near the end of a pith-bearing stem is cut a small orifice communicating with the central bore, and a thin section of the outer bark or rind of the stem is split so as to form the tongue; this is vibrated by gently striking it with a strip of wood, at the same time that air is blown into the tube through the small orifice. The character of the sounds obtained is not given by the ethnologist who describes this primitive instrument.[3]

In occidental countries jewsharps are manufactured on a large scale; they were manufactured in Nuremberg as early as 1524. In Birmingham one dealer, who made thousands of gross in 1895, packed them in boxes labeled 'Irish Harps,' a better designation for trade.

Regarded as an instrument with musical capabilities, the jewsharp was studied by the distinguished English scientist Sir Chas. Wheatstone in 1828. He wrote as follows:

> The jewsharp consists of an elastic steel tongue riveted at one end to a frame of brass or iron (shaped like a horseshoe). The free extremity of the tongue is bent outwards to a right angle, so as to allow the finger easily to strike it when the instrument is placed to the mouth and firmly supported by the pressure of the parallel extremities of the frame against the teeth. The vibrations of the tongue itself correspond with a very low sound, but being placed before the cavity of the mouth, the form and dimensions of which are capable of various alterations by the motions of the tongue and lips, when the number of vibrations of the contained volume of air is any multiple of the original vibrations of the (steel) tongue, a sound is produced corresponding to the modification of the oral cavity.

After specifying the notes yielded by a given instrument, he continued:

> This scale of notes is too incomplete and too defective to allow even the most simple melodies to be played on a single jewsharp, but the deficiencies may be supplied by employing two or more of these instruments.

And he refers to a celebrated performer, Mr. Eulenstein, of whom more anon.

The mouth forms a resonant cavity or sounding box, analogous to the body of a guitar, or to the stretched parchment of a banjo, the pitch varying with the form and size of the cavity; every one has noticed that in pronouncing the vowels *a, e, i, o, u* in their natural order the cubical capacity of the mouth is gradually diminished.

A few persons have acquired such proficiency in playing the jewsharp as to gain recognition in history and literature. Koch, a private in the Prussian army under Frederick the Great, played with extraor-

[3] Bernhard Ankermann, 'Die Africanischen Musik-Instrumenten,' inaugural dissertation, p. 47, Leipzig [Berlin, 1902].

dinary skill, and of him the following story is told. One summer evening, sitting by an open window, the king overheard strains of music of unusual quality, and on making enquiry learned that they arose from a jewsharp played by a soldier doing sentinel duty in the garden. Thereupon Frederick commanded the musician to ascend to his suite of apartments and to play before him, but young Koch politely refused to do so without an order from his colonel. 'But I am king,' said Frederick. 'I know it, your majesty, but I can not leave my post, or I shall be punished.' Although very angry, the king respected the sentinel's candor and fidelity. On the following day Koch, by invitation of the king and an order from the colonel, played in Frederick's apartments and so delighted him that the king gave him a sum of money and an honorable discharge from the army. Koch then traveled through Germany, giving exhibitions of his skill and playing in concerts, whereby he accumulated a moderate fortune. The chief attraction of Koch's playing was his descriptive music, pieces similar to the 'Turkish Patrol'; he used to depict a funeral procession marching along to the tolling of bells, the approach and passing of a chorus of mourners, and their singing of an old German popular dirge.

In the first decade of the century just closed Heinrich Scheibler, of Crefeld, invented an instrument which he called 'Aura'; it consisted of ten jewsharps of different keys grouped in two series of five each and fastened to a disk, with the bows towards the center, so that the jaws diverged like rays. With this combination he performed in concerts before large audiences, producing surprising and beautiful effects.

But by far the most eminent performer on jewsharps was a man named Charles Eulenstein, born in Würtemberg about 1802. He spent many years studying the capabilities of the jewsharp, and being an accomplished musician, he found that the best effects could only be obtained with instruments of different pitch, and he had manufactured sixteen jewsharps, on four of which he was able to play at once by connecting them with silken cords so arranged that he could grasp four with his lips. He appeared in London in 1827–8 and had great success playing in concerts and producing effects greatly admired by amateurs. Eventually his teeth were injured and he had them repaired by a clever dentist, who coated them with some glutinous substance that aided him in supporting the iron instrument. He also performed in Scotland and on the Continent; he was still living in 1878 at Ulm.

Wheatstone wrote of this expert as follows:

> Mr. Eulenstein by using sixteen jewsharps was able to produce effects truly original and of extreme beauty. Those who have heard only the rude twanging to which the performance of this instrument in ordinary hands is confined can have no idea of the melodious sounds which in Mr. Eulenstein's hands it is capable of producing.

GEOLOGICAL HISTORY OF COCKROACHES

By Dr. E. H. SELLARDS,
UNIVERSITY OF FLORIDA

NO insects are more abundant as fossils, and none so widely distributed through the various formations, as are the cockroaches. Their delight in moist places, often near the banks of streams, their firmly chitinized wings and body render them of insects among the best adapted for preservation. Especially are they to be expected in association with ferns and other plants among which during life they found shelter, and together with which they were transported to their resting place in the rocks. Hardly ever will persistent search among fossil leaves of land origin, when imbedded in rocks of sufficiently fine texture, fail to bring to light at least detached wings and perhaps bodies. Even when the bodies of adults have not been preserved, not infrequently will be found the cast-off integument of the young. It is this approximately complete geological record that lends an especial interest to the cockroach family.

The cockroaches have proved themselves a remarkably conservative group having retained throughout their long existence, as compared with other insects, a relatively generalized structure. The development is direct, the young resembling the adults. The mouth parts are of the biting kind common to primitive insects. The segmentation of the abdomen and thorax is distinct. The foot is five-jointed. The venation of the wing is much less complicated than that of many of the more advanced types. Not all the organs, however, have retained this primitive simplicity. In this, as indeed in every group, some organs have outrun others in degree of specialization, so that the group early became a characteristic and well delimited one. The body is flattened, the head small and turned downwards. The covering of the first thoracic segment, the pronotum, is enlarged, rounded, more or less shield-shaped. The front wing is firmly chitinized and lies flat on the back, or slightly arched to conform to the shape of the thorax. An inner area near the base of the wing is marked off by a deep curved line, the anal furrow. The hind wing is less resistant and broader, the greater width being obtained by a greater expansion of the inner border. Hardly ever will a doubt arise as to the reference to this family of even a fragment of a specimen.

The structural characters so far mentioned made their appearance early. The rounded pronotum is as characteristic of Paleozoic as of recent cockroaches. The thick arched front wing with strongly delimited anal area dates from the Carboniferous. The group, however, has by no means remained stationary since the Carboniferous. On the contrary, close observation reveals evidence of advance along distinct and definite lines. The Carboniferous cockroaches are provided with a long ovipositor resembling that of the katydids or crickets; modern cockroaches have a reduced and specialized ovipositor. Early cockroaches no doubt deposited their eggs in the ground or under the bark of trees or within the tissue of succulent stems; modern forms deposit their eggs in a very characteristic egg case. The front wings

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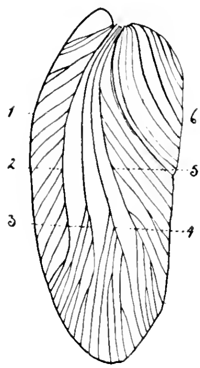

Fig. 1. Front wing of a typical Coal Measure cockroach, *Gerablattina arcuata* Sellards. 1, costa; 2, sub costa; 3, radius; 4, media; 5, cubitus; 6, anal veins. Twice natural size. Author's illustration.

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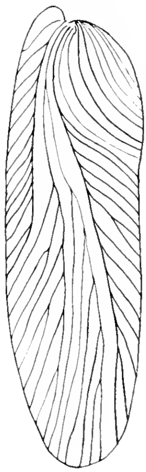

Fig. 2. Front wing of a Permian cockroach, × 5. Original drawing. Gn. sp. new. Author's Mns.

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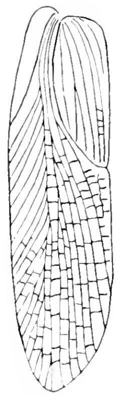

Fig. 3. Front wing of a modern cockroach, *Ectobia germanica*, × 5. Original drawing.

From a comparison of the three types, Carboniferous (oldest), Permian (later), and (Fig. 3) modern, it is seen that: the wing has become increasingly slender and compact; the main veins have become partly fused; cross veins have developed, and the direction of the anal veins has changed.

have become in general more resistant, the venation more complicated. The hind wings have developed plications and a longitudinal fold. The value to biology of a study of the group is in direct proportion to the completeness with which these changes and the laws governing them can be traced out.

The wing of a typical cockroach of Carboniferous time is of simple structure. A border vein, the costa, traverses and strengthens the costal border. Four strong veins arising close together near the base of the wing diverge and supply the greater part of the wing membrane. The first of these, the subcosta, meets the costal border about or beyond the middle length of the wing; numerous superior branches are given off which strengthen the upper edge of the wing. The following vein, the radius, reaches as a rule to the apex, and its branches given off from the upper side fill the apex. The medius, which is often of lesser importance, terminates on the inner border not far from the apex, and gives off a few usually superior branches. The fifth vein of the wing, the cubitus, is of more importance. It reaches along the inner border of the wing one half to two thirds the distance towards the apex, giving off strong inferior branches which strengthen the lower edge of the wing. The remaining small area on the lower inner corner of the wing is marked off by a deep furrow. The veins of this area are all simple or once forked, and pass with a uniform curve from their origin to the inner border.

The next type (Fig. 2) is from later deposits—the Permian. Here two of the main veins, the radius and media, have become fused for a little distance from their origin, so that instead of four strong veins arising from the middle of the base there are here only three. Otherwise the wing is not unlike the Coal Measure form. Many of the mesozoic wings have, in addition to a partial fusion of two or more of the main veins, a further radical change in the anal area, the veins of which, instead of ending on the inner border, run to and end on the anal furrow. The front wing of one of the living cockroaches, the common 'croton bug,' is shown in figure 3. Here cross veins are numerous, and the anal veins, as in most of the Mesozoic forms, end on the anal furrow. The wings described are those which are in a general way typical of their time. Along with each of these are found wings, some of which are more advanced, while others are of more simple structure than those illustrated. Among modern cockroaches not a few genera and species have both front and hind wings so incompletely developed as to be entirely useless, and present only as functionless wing pads. All Paleozoic cockroaches, so far as known, were provided with fully developed functional wings, the modern wingless forms having descended without doubt from winged ancestors.

The hind wings of Carboniferous cockroaches are as a rule broad with rounded inner border; the veins are evenly distributed; there are no cross veins; no indication of any fan-like plaiting such as is found in the hind wings of modern forms; apparently there was no folding, the wing lying spread out across the abdomen. Neither is there any differentiation into a thicker, brownish, outer part, and a thinner, membranous folded part. The hind wing, being less firm than the front, is naturally less often preserved. Nevertheless a considerable number have now been obtained. In the structure of the hind wing the Carboniferous cockroaches present fairly uniform characters, only occasionally, and from late Carboniferous deposits, are there indications that a folding of the wing had originated.

Some of the cockroaches of Permian time, however, had folded and plicated hind wings. A not uncommon type from the Kansas Permian is that shown in figure 5. This wing has a fold running through the anal area at (*b*), on one side of which the veins are longitudinal, while, on the other, they run down towards and end on the line of the fold. The wing in the specimen here illustrated is spread out full width. With other specimens, however, it is seen folded in the resting position, the veins of the two parts showing plainly through the thin membrane. Cross veins in the cockroach hind wing are here seen for the first time. A beginning of plication is also evident in the area between (*a*) and (*b*), while between the veins are developing accessory longitudinal veins necessary to support such plications. This wing also gives additional evidence of what had been previously demonstrated—plications, although now common to the hind wings of Orthoptera in general, nevertheless originated independently in several families of the order after they had diverged as distinct lines from the main stock. A similar need among the several families is here met by the development in each of a similar mechanism.

The hind wing of modern cockroaches presents a further development of the structures originating with these early ancestors. The hind wing is made to fit nicely under the front by a longitudinal fold. The wing is strengthened by numerous cross veins, and the anal area is very perfectly plicated. An increased expanse of the anal area is accompanied by a relative reduction in the other areas of the wing, especially the cubital. The folded area has remained flexible, while the more exposed part of the wing has become thicker, more resistant, and brownish in color.

This progressive change in the wing structure is accompanied by the reduction of the ovipositor from the long sword-shaped organ of the Carboniferous cockroach to the specialized organ of recent forms adapted to the purpose of holding and guiding the eggs into the egg case. Other organs of the body, if closely followed, would, doubtless, give evidence of similar progressive change. The organs described are those most readily preserved, hence best known in the fossil condition.

The young of any group of organisms are always of interest. A considerable number of young cockroaches have been found in the fossil condition, occurring often in deposits where the bodies of adults are rarely or never seen. In most cases the parts preserved are not the bodies of the young, but the cast off integument shed by the young cockroach with each successive molt. The body is heavy and transported with difficulty, the soft tissue hastens its decay, or more probably it is gathered up as food by the horde of hungry animals in the water or on land. It is not so with the molt, for it is useless as food, and like the detached wings with which it is always associated, is light and easily floated by rains into streams and rivers, and thence carried by currents into larger bodies of water, where permanent deposits are accumulating. Both wings and molts are fairly resistant to decay, and thus more readily preserved than are the softer parts of the body. Such molts have been found in this country from the Coal Measures at Mazon Creek, Illinois; from the Upper Coal Measures of Eastern

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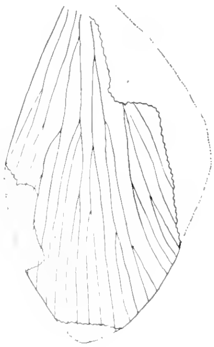

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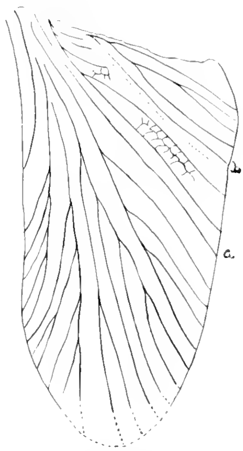

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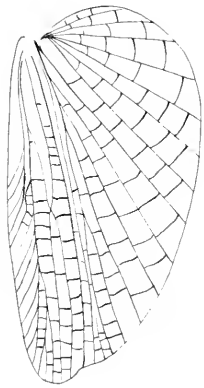

Fig. 4. Hind wing of Carboniferous cockroach, *Promylacris rigida* Scudder. Twice natural size. Author's illustration.

Fig. 5. Hind wing of a Permian cockroach, × 4. Original drawing.

Fig. 6 Hind wing of a modern cockroach, *Ectobia germanica*. Original drawing.

The conspicuous changes in the hind wing as seen here are increased expanse of the anal area, increased proportionate breadth of the wing, origin and development of a longitudinal fold, development of plications in the folded area of the wing, development of cross veins.

Kansas; and from the Permian of Central Kansas. Recently an interesting specimen, shown in the accompanying illustration, has come to light from the Coal Measures of Clinton, Missouri.[1] A few specimens have also been obtained from the coal formation of Scotland. The young of Paleozoic cockroaches closely resemble the adults, and were evidently in form and habits very similar to young cockroaches of the present day.

The cockroaches of Carboniferous time are, on a general average, larger than those of later time. The largest described form, *Archoblattina Beecheri* Sellards, has a body, exclusive of the head, three and one half inches long, with an expanse of wings of six and one fourth inches. The Permian forms, and, also, those from mesozoic and later formations, are, so far as known, smaller than those of the Carboniferous.

There appears to be no authentic record of the occurrence of cock-

[1] Collected by Dr. J. H. Britts and transmitted by him to the National Museum. Kindly submitted to the writer for illustration by Dr. David White.

roaches in any rocks older than the Carboniferous. The single specimen reported from the Silurian of France is at best very unlike a cockroach. Its claim to affinity with the cockroach group was long ago contested by Scudder, and even Brongniart, its discoverer, has since conceded that it can not belong here. Other writers exclude the fossil entirely from the class Insecta. The oldest known species appear to be *Archimylacris parallela* Scudder and *Gerablattina fascigera* Scudder, from the Millstone Grit, or Middle Carboniferous. During Coal Measure time cockroaches became extremely abundant, more so than in any later period. They are less numerous in Middle and Upper Permian as well as in Mesozoic and later deposits. Nothing whatever is known of the insect life of the southern hemisphere during either Paleozoic or Mesozoic, and it yet remains to be seen what forms will be brought to light from this part of the world. During the Carboniferous and Permian, cockroaches were widely distributed over Europe and North America. With the uniform climatic conditions of that time it can hardly be doubted that their distribution was as wide at least as that of the tropical plants with which they are so constantly associated.

FIG. 7. Young of a Coal Measure cockroach, × 4. Original drawing.

Among the laws of development operative in bringing about the changes which have occurred in the cockroach family during its long geological history, those the effects of which are most apparent may be summarized under the following headings:

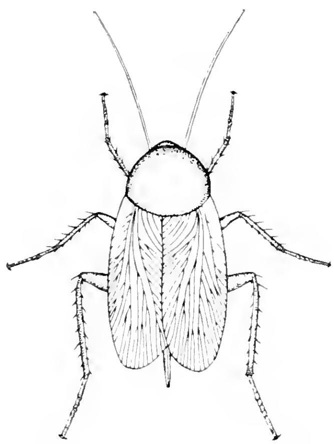

FIG. 8. Natural size restoration of a typical Coal Measure cockroach, *Etoblattina mazona*. The protruding ovipositor and simple wing venation distinguish Coal Measure from modern cockroaches. Author's illustration.

Recapitulation of Ancestral Characters.—During the nymph stages of a modern cockroach the venation of the immature wing is not unlike that of the typical Coal Measure adult. The main veins of the wing, which during these early stages are free to the base, later become more or less fused and cross veins appear, thus illustrating the law common to most groups of organisms and known as a recapitulation of ancestral characters.

Parallel Evolution.—A similar need among the several related families of the order Orthoptera to which the cockroaches belong has been met by the development of identical structures. Thus both the plications and the fold of the hind wings originated independently in the cockroach and some other families of the order.

Mechanical Principle.—Both the plications and the longitudinal fold of the Orthoptera wing seem to have been developed in response to the mechanical need of some means of caring for the largely expanded inner area of these wings.

Specialization by Reduction.—The reduction of the long ovipositor of early cockroaches to the short specialized ovipositor of modern forms is apparently an illustration of the law of specialization by reduction.

Loss of Organs Through Disuse.—The reduction of the wings of several modern species to such an extent that, although presenting normal adult features of venation and articulation to the body, they are so far vestigial as to be practically functionless, is doubtless to be attributed largely to lack of use, and results from the ground habits of these insects in which they use the wings comparatively little. Not infrequently functional wings are retained by the males, even when lost by the probably less active females of the same species.

Arrestation of Development.—The wings of not a few modern forms remain as nothing more than wing-pads similar to the wing-pads of the larval stages. This further reduction is probably an instance of what has been called arrestation. Although other organs of the body have reached maturity, the wings, checked in their development, have not passed beyond the larval stages. Lack of use of the wings by the ancestors of the species, and consequent insufficient blood and food supply to this part of the body, is probably in this case an indirect cause of arrestation.

HOW ROOTING AQUATIC PLANTS INFLUENCE THE NUTRITION OF THE FOOD FISHES OF OUR GREAT LAKES

By Professor RAYMOND H. POND

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A THOROUGH investigation of the biology of our great lakes is in itself a desideratum worthy the expense. From the purely economic standpoint, however, our Bureau of Fisheries has long recognized the necessity of knowing more of those conditions under which products worth millions annually are produced. Until such an investigation has been made the natural factors which determine the quantity of food fishes these lakes can support must remain unknown.

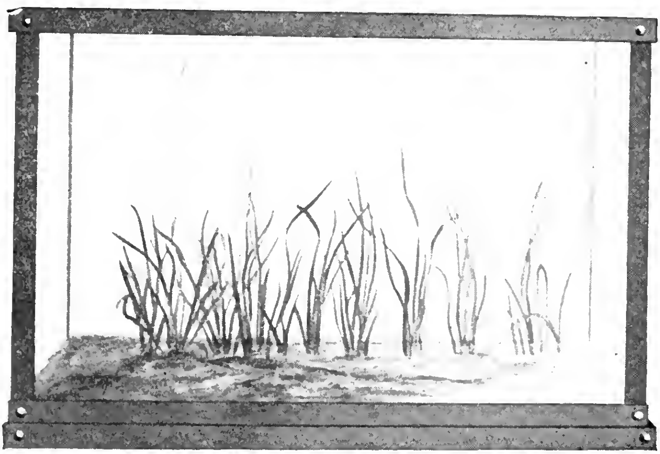

Fig. 1. *Vallisneria spiralis* after 7 weeks' growth rooted in lake soil. Plants in figures 1 and 2 originally the same size.

Fish, as all other living forms, reproduce in a geometrical ratio and, other conditions being favorable, will multiply up to the limit of their food supply. Thus it is that the problem of nutrition is very fundamental. To determine the source of nutrition of our fresh-water food fishes is in itself a considerable undertaking, but to ascertain what factors regulate the quantity of this nutrition is a colossal task.

The nutrient relations of aquatic life are perhaps no more complicated than those of terrestrial, but they certainly are more difficult to determine because of the numerous obstacles to observation and collection of data. The higher orders of animal life are, of course, dependent upon the lower. The low free-swimming forms, called collectively zooplankton, are preyed upon by larger animals. The latter in turn are devoured by still larger forms and so on up to the fish. It is evident that all the animals above the zooplankton are dependent upon it, and whatever increases or decreases the quantity of zooplankton causes a fluctuation in the food supply of the fish. Thus it is that a quantitative study of the plankton forms so conspicuous a feature of the extended investigations which have been made both here and abroad of fresh-water biology.

Aquatic animals, just as terrestrial, are dependent upon plants for the organization of the elements of food into food. As there is an animal or zooplankton, just so there is a vegetable or phytoplankton. The latter is the living basis of the food supply of the aquatic fauna.

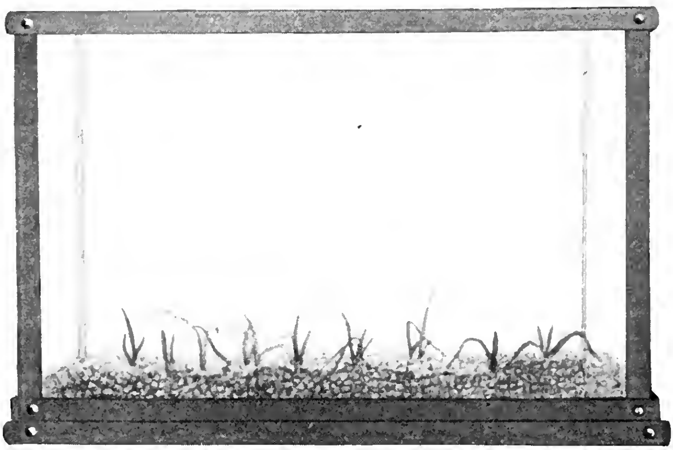

FIG. 2. *Vallisneria spiralis* after 7 weeks' growth rooted in gravel. Plants in figures 1 and 2 originally the same size.

This phytoplankton lives on substances which it makes for itself out of carbon dioxid and water and the mineral matter in solution in the water. The supply of water and carbon dioxid is, of course, unlimited. The supply of mineral food varies considerably in different bodies of water and in the same lake several factors may operate to cause a fluctuation. The rooting aquatic plants have long been suspected of being one of these factors, but whether they increase or decrease the mineral food has not until recently been known.[1]

The rooting aquatic plants may be considered in two groups according as they are submerged or emergent. The latter vegetation must,

[1] Pond, Raymond H., 'The Biological Relation of Aquatic Plants to the Substratum,' U. S. Fish Commission Report for 1903, 483–526, published 1905.

of course, take its nourishment from the soil. It has long been believed, and the statement is current in our latest and best text-books, that the submerged and rooting aquatics take their nourishment from the water which bathes them, that their roots are not for absorption, but merely for anchoring. An examination of the literature convinced me that so far as experimental evidence is concerned there is none which can be accepted as demonstrating this conclusion or a contrary one. The necessity of exact knowledge in this particular is apparent when we consider that if such plants, as hitherto supposed, feed from the water, they then during the entire growing season are diminishing the quantity of food for the phytoplankton. On the other hand, if

FIG. 3. *Vallisneria spiralis* after 5½ weeks' growth in loamy soil.

FIG. 4. *Vallisneria spiralis* after 5½ weeks' growth in sandy soil.

this food comes from the soil they not only do not reduce the plankton food supply, but actually become important contributors to it in that the mineral food taken by them from the soil finally through their decay becomes available to the phytoplankton. That the latter alternative is the true one may be seen from the following glimpse of an experimental study.

The special organs of absorption in terrestrial plants are the delicate root hairs which occur on the young roots in a narrow zone situated just back of the growing tip. The quantity of such hairs can, in the laboratory, be made to vary greatly by regulating conditions, showing that they are sensitive structures and not likely to be produced unless needed by the plant. Some land plants are known which do not have root hairs, but they are exceptions. On the other hand, aquatic plants have been supposed to be without such hairs. Examination of specimens taken from the lake bottom very carefully revealed their presence, however, and aquarium cultures in the greenhouse show that, like those on land plants, they are sensitive to the conditions of their environment. The presence of such hairs is almost *prima facie* evidence that the organs bearing them have an absorptive function in addition to an anchoring one. This conclusion was tested in several ways. It was found that such plants could not make a normal growth unless rooted in favorable soil. Clean washed sand could not be substituted for good rich soil. Likewise a clay soil does not support a normal growth. Thus we find that these aquatics are quite sensitive to the nutritive quality of the substratum. In fact their existence depends upon this, as none of the larger plants growing submerged in western Lake Erie can mature a generation on the nourishment they are able to secure from the water alone. Chemical analysis shows that plants which have been denied soil nourishment are deficient in nitrogen, potash and phosphoric acid, as compared with others allowed to root in the soil.

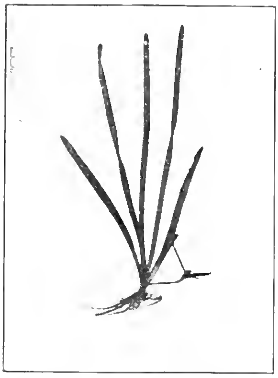

FIG. 5. *Vallisneria spiralis* after 5½ weeks' growth in clay soil.

Some plants are more dependent upon the soil than others, thus *Ranunculus aquatilis* made 63 per cent. better growth in soil than in clean washed sand. *Elodea canadensis* made 340 per cent. and *Potamogeton perfoliatus* 480 per cent. better growth in soil than in sand. Such results show clearly how important a place the rooting aquatics occupy in that chain of nutrient relations which stretches from the fish down through the orders of animal and plant life to the soil.

In the stocking of ponds for fish culture attention should be given to the plants allowed to grow. The species mentioned above are favorable, while *Ceratophyllum* is not. The latter plant often makes a very abundant growth. Though frequently accidentally anchored to the bottom, it does not bear roots and must, of course, take its nourishment from the water. A small lake in which this plant had made a very abundant growth was found by another investigator to have less plankton than other neighboring lakes in which the bulk of the vegetation was rooting.

URBAN AND RURAL LIFE

BY FRANK T. CARLTON

AT the beginning of the twentieth century, approximately one third of the total population of the United States were living in cities, and were classed as urban inhabitants. A considerable percentage of this twenty-five million human beings are to-day living in crowded and uncomfortable quarters, despite the evident fact that there exist in nearly all sections of the nation many valuable abandoned farms and half-deserted villages. The exigencies of manufacture and trade, and the glamor and hurry of city life, as contrasted with the dullness and monotony of rural existence, have gathered this great host of men, women and children into our crowded, smoky, restless cities. In the building of the modern manufacturing and commercial city, everything held dear by the poet and the lover of humanity has been ruthlessly and heedlessly sacrificed on the altar of industry and wealth. Human life and happiness have been overlooked or ignored in the mad scramble for wealth, trade and power. Exports and imports, bank clearances, cotton, sugar, oil, beef, iron and steel, not men, or women, or children, are the important and desirable, even the paramount, considerations. Human health and human weal are thrown in the balance against gold and silver, and are found wanting. The unparalleled growth of cities during recent decades is, in a large measure, to be attributed to modern methods of transportation of goods and people, and of transmission of energy and intelligence. Change the conditions in regard to any one of these items, and the forces which make for centralization or decentralization are modified or reversed. Railroads and electric wires, telephones and telegraph instruments, rural free delivery and good roads are important factors in the distribution of population.

Great populations have migrated from country to city; long-established modes of living are quickly changed; old customs and habits, upheld and cherished by the dearest traditions, are suddenly brushed aside. A race of city dwellers is being developed. On the very threshold of a new century these questions are forced upon a reluctant people: Can a nation grow strong, vigorous and progressive if a large percentage of its population are dwelling in cities? Is city life natural? Is the sharp demarcation between rural and urban conditions conducive to healthful political activity? Are decentralizing tendencies becoming noticeable?

History records many rhythmic movements in human society. Certain tendencies are developed and carried to an extreme; but sooner or later new forces appear which produce a reaction; and the pendulum swings backward. The flood tide of city migration is near; an ebb toward the rural districts may be anticipated. Indeed the stream of population flowing toward the cities is being, in a measure, diverted into suburban channels; and at the same time a counter current is setting in from the crowded tenement-ridden quarters toward the more healthful outskirts of the city, where grass and trees are not wholly unknown. Our modern cities, our great manufactories, our railroads and our enormous trade are the results of the extensive use of steam power. While factories and cities did exist before Watt made his famous invention, conditions were radically different from those of to-day. Steam has molded our present civilization. But in recent years a new distributor of power, electricity, has come into extensive use. As a result the economies and limitations which caused centralization and crowding during the century of steam are removed to some extent. Electricity is modifying the distribution of population.

The movement toward the suburbs can be noticed by even a casual observer. Manufactories and residences are being built in the suburbs. Factories and homes are no longer erected in close proximity to each other. Shops are now designed to occupy a larger ground area, and are located further from each other. The age of decentralization is just ahead; the suburb is absorbing more and more of our city population.

The suburban type is becoming characteristic; the commuter is a constantly increasing factor among our people. Improved methods of communication and of transportation, better roads, rural mail delivery and new methods of transmitting power are substituting decentralizing for centralizing forces. As the country is covered with a network of trolley and telephone wires, the area available for the residence of city workers is enlarged. The use of elevated roads, inside the city limits, for suburban electric lines will still further lengthen the radius of the circle. Country or suburban homes, equipped with many city conveniences and advantages, are now available for the man engaged in business in the city. Country life of the immediate future is not to be what it was in the 'good old times'; new forces and new influence are infusing new life into the rural communities. Rural isolation will soon be a thing of the past in nearly all sections of the eastern and north central states.

The American people are beginning to recognize vaguely that life in a crowded city is not the best and most wholesome for men and women. Many individuals are buying homes in the country for purely sentimental reasons. But behind this sentiment is an unerring instinct which leads us back to contact with the soil and to communion with nature, to a simpler and less artificial kind of living; and also in the shadow of sentiment is an industrial situation which is steadily losing its antagonism to this instinct.

Furthermore, at the very moment when the forces of decentralization begin to make themselves manifest to the keen observer, a determined demand for governmental regulation of railroad rates appears. Railroads, as everybody understands, have played an important rôle in assisting the enormous growth of population at certain geographical points; they have undoubtedly wielded the power to build up towns and cities, or of retarding their development. Railroad companies have often exhibited a disposition to punish the small town, particularly if its location is such that there is little or no competition in regard to transportation. While electric lines offer indeed a partial remedy for this unfortunate situation, measures directly affecting the steam lines are needed, if this discrimination is to be entirely removed. If the United States government is in the future to take an active part in the control of railroads and the regulation of railroad rates, the people must decide whether centralizing or decentralizing forces shall be aided by the railroads, whether the large city shall be favored over the smaller one or the town, and whether the large shipper shall be permitted to receive special privileges in the shape of reduced rates on large or frequent shipments or for goods shipped under peculiar conditions, as, for example, in private cars. In the discussion of railroad-rate regulation the question of the treatment of small towns as compared with that accorded to cities ought not to be ignored. If railroad rates are to be determined or modified by governmental action with a view of benefiting the general public, we must decide whether the suburban type is desirable in the immediate future. We must, knowingly or unknowingly, stand for or against centralization of population and manufacture. Shall we use the power to regulate freight and passenger rates so as to accelerate or retard the growth of the suburbs? What is to be our attitude on this question? Shall we use the forces of legislation so as to act with or contrary to those economic and physical forces which are building up the suburbs, and which work unceasingly to mold our civilization into the suburban type?

As mankind becomes more highly civilized, wants become more numerous and varied. In a century, the civilized world has been advanced from a condition of penury to one of plenty; life is now more complex. The luxury of yesterday is the simple life of to-day. Requisitions for food, clothing and shelter are supplemented by demands for intellectual, social and esthetic enjoyment. Since machine production is employed chiefly in satisfying the demand for the common necessities of life, and because skilled and artistic work is necessary to create those articles and to furnish the services which particularly appeal to the artistic and esthetic demands of man, as wants of this latter sort develop, skilled workers will be gradually transferred from one class of industry to the other. Successful skilled workmen require clean, commodious and healthy home and shop environment. A demand for skilled craftsmen points toward a revival of village industry; because in the village or the suburbs only, as a rule, can such an environment be found at an expense which is not prohibitive. The use of water power and electrical transmission is especially suitable for furnishing power to small establishments. An authority on this subject has recently stated that about four fifths of the total water-power of the United States is found in falls furnishing less than one thousand horse-power; and that many now unutilized falls may be acquired and equipped to furnish electrical energy at a very reasonable cost per horse-power developed. The economic and industrial advantages are not all monopolized by the large business; but governmental regulation of railroads and of the exploitation of natural resources can also do much toward giving the small fellow and the small municipality a 'square deal.'

The steady increasing attention granted to art, architecture and the crafts movement, and the growing demand for public parks and playgrounds, are not entirely disconnected or distinct from the movement toward the suburbs. This latter movement has, to date, chiefly affected the well-to-do and the better paid class of artisans; but it is destined to persist until the homes and the environment surrounding the poorest are bettered. The cities are indeed growing very rapidly; but the foreshadowing of a new, more hopeful movement is there in their midst. Every demand for civic beauty and cleanliness is a demand for space and rapid transit.

A cursory glance at the worker employed in machine production reveals the fact that he has been reduced to the position of a mere machine tender. Long hours devoted to this kind of work makes a man narrow, it blunts his sensibilities; he finally becomes like unto the machine he tends. Machine production is a necessary accompaniment of our civilization; the machine is to remain among us, nor do we wish to dispense with its services. The machine must be used so as to benefit, not degrade mankind. The hope of the worker is in a shorter working day. If a shorter working day is obtained will the worker, is he able to, improve his leisure time? In other words, is a desirable and beneficial use of leisure time probable in the crowded portion of a city with its dull, monotonous scenery; its noise, hurry and smoke; its foul odors, bad streets and worse places of amusement or debauchery; its lack of natural scenery, fresh air and wholesome food? Amelioration of conditions is possible, feasible and desirable; but a movement of manufacture to the suburbs, the development of rapid suburban transit, the revival of village industry in the skilled trades and education which tends to raise the standard of living, are the real panaceas for the evils of the crowded city. Our statesmen can aid in hastening the solution of the problem by directing their attention toward the regulation of steam and electric railroads.

Agriculture also is undergoing a transformation; it is changing, in this country, from extensive to intensive methods. Our greatest industry does not readily lend itself to consolidation and combination. The small and medium sized farm triumphs, in the long run, over the bonanza farm, except perhaps in the cultivation of such crops as cotton, sugar-cane and tobacco, where the plantation system seems destined to continue. As the population increases the big farm breaks up and disappears, leaving several smaller ones in its place. Farming must, therefore, be classed with those occupations which do not readily submit to minute division of labor, or extreme specialization of industry. Scientific agriculture must be classed among those industries or trades which require skilful and artistic individual work. Its possibilities are not generally realized. The era of free public land is practically over. Men can no longer go west and take up new, unbroken ground. A few decades ago the competition of the newly opened western lands injured temporarily the farming regions of the eastern and north central states. To-day the situation is changing, many western farms have been robbed of their virgin fertility by uneconomical and short-sighted farming, and the eastern farmer is daily finding new opportunities for profitable agriculture. Dairy farming, stock raising, horticulture and market gardening are more and more attracting his attention. Scientific methods are being adopted; renewal of soil fertility is the first care. The 'good' farmer is one who makes a profit at the end of the season, and who also preserves unimpaired the fertility of the soil. To be a successful farmer in this country it will be necessary to have definite ideas regarding farm management, and the proper methods of crop rotation and fertilization must be understood. Business methods must be adopted, and the cost of each crop must be accurately determined. The farmer will be obliged to keep in close touch with the industrial and commercial life of the nation. Agriculture will be a business, and business principles will be applied. The era of the unscientific, haphazard, go-as-you-please style of farming is rapidly becoming obsolete. The rise of the agricultural college and secondary school, and the potent influence of the United States Department of Agriculture, together with the general introduction of the trolley, the telephone and rural mail delivery, mark a new and promising epoch in the history of American agriculture. The agricultural transformation will diminish the drain of ambitious young men from the farm to the factory, the store and the bank.

The formation of a numerous and influential suburban type of people may, therefore, be anticipated for three reasons: the introduction of new methods of transmitting and distributing power; an increasing demand for goods of a varied, unstandardized character; and the development of scientific intensive agriculture. The development of such a social type may be hastened by appropriate legislative action. The city will gradually take on many desirable rural characteristics; and, on the other hand, the country will receive the benefits of many hitherto purely urban conveniences. The characteristic rural and urban types will present fewer dissimilar and discordant features. Decentralization—the merging of the urban and rural into the suburban—only can remove the well-known antagonism between the interests of city and country. State political machines have been constructed upon the foundations laid and cemented by this mutual antagonism and distrust between the city man and the farmer. True representative government breaks down and becomes a farce in the face of such an unfortunate situation. This line of demarcation may, as the suburb grows, be expected to fade away until the two types blend into the suburban; and then the forbidding menace to our democratic institutions caused by the distinct and often divergent interests of country and city will be, in a large measure, removed. Legislative power can not initiate or suppress such a social and industrial movement, but it can accelerate or retard such a tendency.

NEWSPAPER FOOTBALL

By Professor EDWIN G. DEXTER,
UNIVERSITY OF ILLINOIS

THAT the game of football as played at our schools and colleges is in ill repute with the people as a class, no one who keeps at all abreast of the times can deny. Nor can it be denied that there are many good reasons for the feelings of general disapproval. The game, in common with other athletic pursuits, puts an undue premium upon certain human (or inhuman) characteristics which are altogether at variance with the highest ideals of the institutions which maintain it. It has too, in some instances, established relations that are to be regretted with professional interests and professional methods. It has, through its immense popularity and consequent tremendous gate receipts, given rise to financial problems that are not easy of solution, and it is, according to the newspaper, seemingly excessively dangerous to life and limb. In spite of the gravity of the other deplorable features of the game, we can hardly doubt the present wide-spread revulsion of popular feeling is due most largely to the last mentioned cause, for it is the one most prominently before the people. The others are treated in an academic wayin occasional articles and editorials which are read by comparatively few people, but during the football season no reader of the daily papers can fail to be impressed with the great number of news items, each relating to some fatality or instance of serious injury on the gridiron. Hardly a Sunday issue of any of our principal city dailies has appeared during the past football season without including from three to a dozen or even more of such paragraphs till one was led to wonder whether any of our pig-skin warriors would survive the campaign. So much at variance were these reports with prevailing sentiment and conditions in a few football quarters with which I was personally familiar that I was led at the close of the last football season to endeavor to find out whether the report fitted the facts more exactly in others. This I did by writing personal letters to all those reported 'seriously injured' in a number of the leading daily newspapers of the country. Each letter specified the particular injury reported, as well as the date of the game and asked the following questions:

1. Were you in good training?
2. How much time did you lose from school work because of the injury?
3. Have you entirely recovered?
4. Is there any probability that the injury will prove permanent?

In all 135 letters were sent out: 78 to players upon college teams; 39 upon public school teams—mostly high school—and 13 to players upon athletic-clubs and other unclassified teams.

Before discussing the particular replies to the letters, I wish to say that I recognize fully that in appealing for information to football men I am going to interested witnesses for testimony. If these men had not been partizans of football they would not have played the game and consequently would not have been injured. Yet the questions are largely those of fact and not of mere opinion, and I doubt if we should in any important way impeach their testimony. I recognize, too, a possible basis for criticism in my making the loss of time from class work the criterion for judging the seriousness of the injury suffered. It is probably true that one might meet with serious or even ultimately fatal mishap on the football field without immediate incapacitation for classroom work. Yet such cases would be in all probability exceedingly rare, and the question of class-absence taken in connection with the next two questions would seem to be sufficiently conclusive. If one had lost no time from an injury which at the time of answering the query—some weeks later—was entirely recovered, it would seem as if the injury was of no great consequence. Certain it is that no interference with the main aim of college life, *i. e.* study, had been suffered. The only other sufficiently definite criterion for the measure of the injury would be that of enforced absence from football practise. This does not seem to me to be as fair a basis of judgment as the other, since it means to measure the perfection of physical condition not by an ordinary, but by an extraordinary, physical stress. It would also involve the problem of saving a man for a particular game rather than keeping him out purely and simply because of the injury, and would thus tend to introduce error.

Up to the time of writing this paper (January 20), 84 replies have been received, 60 of which are from college men, 22 from high-school players and 2 from others. Twenty-four letters, have been returned marked by the postmaster 'no such person in the directory.' An analysis of the 60 replies from college men shows the following somewhat interesting facts:

First, that 14 of the number assert the entire falsity of the report; in one or two instances the man had not even played the game in question; in the rest, any injury whatsoever is denied.

Second, the 46 other college men acknowledge the report as true in a general way. Of this number, however, 24 say that the injury was the merest trifle and that *no time whatsoever was lost* from classes.

Third, the time lost from college work on the part of the 22 college players who specify some loss as follows:

1 hour	1
1 day	2
2 days	4
3 days	1
1 week	5
1 to 2 weeks	2

The remaining seven report a longer time averaging about a month, though three say 'am staying out until Christmas.'

Fourth, of the 60 college players reporting, twelve stated that at the time of answering my letter they had not wholly recovered from the injury. When we consider that in some instances the reply was made within a week or two of the time of injury and in no instance more than two months after, this number does not seem excessive. With the exception of the persons noted under fifth, the answers seem to indicate the later stages of convalescence. Some of them read: 'muscles still weak,' 'leg still in plaster cast but will be out in a few days,' 'still a little lame,' 'three teeth not yet recovered, but dentist doing his best,' 'ankle a little stiff yet' and 'have not fully recovered but was able to play the Nebraska, Wisconsin and Chicago games' (this from a Michigan man).

Fifth, on the part of five players it could not be said with certainty that the injury would not prove permanent. Michigan, Columbia, Harvard, Chicago and Illinois each has one in this class. For these men the particular injury and the reply to the question as to permanence are as follows:

(1) Ligament of knee ruptured. 'Can't say definitely. Think not.'

(2) Spine wrenched. 'Physicians say I shall ultimately recover.'

(3) Blow on head. 'My orders from the doctors are: If you remain quiet and take good care of yourself you will entirely recover.'

(4) Partial detachment of retina. 'It is not unlikely that a part of this area will remain permanently detached from choroid.' (Signed by physician).

(5) Knee injured, floating cartilage. 'Very serious and, unless an operation could eliminate it, the danger of a very unreliable knee.'

This completes the record of the college men, except for the fact that all but five assert that they were in good training. This, however, means nothing in itself, since we have no means of knowing what proportion of the whole number of men playing football were unseasoned.

With the high school players, the facts seem to coincide more nearly with the printed reports. Of these, twenty-two in all, but two denied the report in toto, although eight others stated that no time was lost from classes. The rest on the whole lost a considerably larger average of time than did the college men. A delightfully optimistic lot of boys were these gridiron youngsters, not one of whom would grant the slightest possibility of permanent injury. One acknowledged 'a fine headache for several days and a slightly crooked nose which was the fault of the *Docktor*.' Another adds: 'And I am glad to say I couldn't carry out the ashes.' Only eleven dared say that they were in good training.

In their bearing upon the purpose of this study, which was, as I have said, to determine if possible the accuracy of newspaper reports of football injury, what do these returns mean? Seemingly, so far as college players are concerned, they tend to prove the utter unreliability of the press reports. What are the facts in support of this? Seventy-eight reports of 'serious injury' to college men appear in a single season, many of them described in detail and under 'scare headlines.' From sixty of these persons replies were received, while the letters addressed to fourteen others are returned unopened, indicating in all likelihood that there was no such person, since in every instance the name, the team and the words 'football player' were on the envelope. And of the sixty heard from, but five can, it seems to me, with any degree of fairness be considered 'seriously injured,' and with them it is a question. Upon such reports is the present popular revulsion against football founded. Nor is the condition that I have pointed out either local or of recent standing. The reports that I have studied appeared in papers in all parts of the country, and a series of letters sent out by me at the close of the football season of 1902 gave results in no way differing from these. Of twenty-three college men reported seriously injured that season, 2 stated that the report was false; ten lost no time, and in every instance recovery was complete. If it were not for the tragedy of it all, some of the reports would be better fitted for the comic supplement than the news columns. Note the following that appeared in a leading paper at the close of the last season under heavy headlines, '*The Dead and How They Were Killed*.'

LATIMORE, JOSEPH, at Mukwonago, Wis. September 13. He was rubber down for the Northwestern University team at the training camp at Mukwonago. He had been left at quarters while the team went for a row. The manner of his drowning is not known. The body was found the next day.

The entire list contained the names of 18 others, who are presumably dead and supposedly so from the direct effect of football. Within a comparatively recent time one of the foremost daily papers of the country appeared with the scare headlines 'Football Player Killed,' for no more valid reasons in one case than the killing of an ex-football player by the cars on a grade crossing, and the other the electrocution of a boy on a scrub team, who had climbed an electric-light pole to remove the ball, which had, by accident, lodged in the lamp. Such mishaps should not be charged up to the game. No advocate of the game of football should fear the truth so far as the dangers of the game are concerned, yet every believer in it has a right to resent the unfair playing upon popular fears and emotions by a public press that is either culpably careless in the gathering of news, or worse.

Football is not a gentle game, and the boy who is entirely satisfied with tiddle-dy-winks, as well as his father, who in his day had been satisfied with similar games, may deem it over-strenuous. But no youth of bone and muscle who hears even the faintest 'Call of the Wild' echoing down from a thousand generations of fighting ancestors—and they must have been fighters or they would never have been ancestors—comes to his own without somewhere and somehow a chance at the physical try out with worthy adversaries. With the days of almost universal war superseded by days of as universal peace and the knight-errant and the tournament things of the past, if we emasculate football and attempt to eliminate entirely the danger element, we shall close the last safety valve to virile expression and may well expect an explosion. Newspaper football is excessively dangerous, but is, after all, football of the college gridiron? In a statistical study which I have made covering ten years of play (1892–1902) in sixty-four leading colleges and universities, where 22,766 men played upon 1,374 different teams, but three men were fatally injured, eight permanently injured and but three men in each hundred sufficiently injured to lose time from their class work. And Harvard was within the list studied, in spite of what might be inferred from reports for the past season. President Hadley was right when he said a few days ago that football was not only not an excessively dangerous game as played at our colleges, but the least dangerous of the more important sports. But he was not speaking of newspaper football.

SUBMARINE NAVIGATION[1]

BY SIR WILLIAM H. WHITE

SUBMARINE navigation has engaged the attention of inventors and attracted general interest for a very long period. Its practical application to purposes of war was made about 130 years ago. The main object of that application was to threaten, or if possible destroy, an enemy's battleships engaged in blockade by means of under-water attacks, delivered by vessels of small dimensions and cost, which could dive and navigate when submerged. From the first, submarines were admittedly weapons favored by the weaker naval power; and as a consequence their construction found little favor with our naval authorities. Under the conditions which prevailed a century ago in regard to materials of construction, propelling apparatus and explosives, the construction of submarines necessarily proceeded on a limited scale, and the type practically died out of use, almost at its birth. Enough had been done, however, to demonstrate its practicability and to make it a favorite field of investigation for inventors, some of whom contemplated wide extensions of submarine navigation. Every naval war gave fresh incentive to these proposals, and led to the construction of experimental vessels. This was the case during the Crimean War, when the Admiralty had a submarine vessel secretly built and tried by a special committee, on which, amongst others, Mr. Scott-Russell and Sir Charles Fox served. Again, during the civil war in America, the Confederates constructed a submarine vessel, and used it against the blockading squadron off Charlestown. After several abortive attempts, and a considerable loss of life, they succeeded in destroying the Federal *Housatonic,* but their submarine with all its crew perished in the enterprise.

It is impossible to give even a summarized statement of other efforts made in this direction from 1860 onwards to 1880; but one cannot leave unnoticed the work done in the United States by Mr. Holland, who devoted himself for a quarter of a century to continuous experiment on submarines and eventually achieved success. The Holland type was first adopted by the United States Navy, and was subsequently accepted by the British Admiralty as the point of departure for our subsequent construction of submarines. In France also successive designs for submarines were prepared by competent naval architects, and a few vessels were built and tried. The *Plongeur,* of 1860, was a submarine of large size, considerable cost and well-considered design; but her limited radius of action and comparatively

[1] An address before the Royal Institution of Great Britain.

low speed left her for many years without a successor on the French navy list. The high relative standing attained by the French navy as compared with our own, in consequence of the vigorous action of the Emperor Napoleon III. in developing steam propulsion and armor protection for sea-going ships, no doubt greatly influenced French policy at that time, and delayed development of submarine construction. When conditions were altered in consequence of the Franco-German war of 1870, and the position of the French navy in relation to the British became less favorable, it was natural that the question of submarine construction should assume greater importance in France. In the interval, moreover, great advances had been made in materials of construction and in means of propulsion available for submarines. The extended use of steel and the practical applications of electricity gave to designers greater facilities than existed previously, and public interest in the construction of submarines and small swift vessels was increased by the writings of the *jeune école,* who strongly condemned the continued construction of armored 'mastodons.'

The modern development of submarines for war purposes is chiefly due to French initiative. During the earlier stages of this development progress was extremely slow. The *Gymnote* was ordered in 1886 and the *Gustave Zédé* in 1888, and her trials continued over nearly eight years, large sums of money being spent thereon. In 1896 competitive designs for submarines were invited, but no great activity was displayed in this department of construction until the Fashoda incident two years later. Since that time remarkable developments have been made in France, considerable numbers of submarines have been laid down, rival types have been constructed, and many designers have been engaged in the work. Up to the present time about seventy submarines and submersibles have been ordered; in July, 1904, the total number of completed vessels was twenty-eight; and at the end of 1907 it is estimated that France will possess sixty completed submarines, with a total displacement of nearly 13,600 tons. The first French submarine of modern type, the *Gymnote,* was 56 feet long, and of 30 tons displacement. The latest types are nearly 150 feet long and of 420 tons displacement. The cost of a French submarine designed in 1898 was about 26,000*l.* The estimated cost of the latest and largest vessel is about 70,000*l.* The French have pursued no continuous policy in this development, but have alternated between vessels of comparatively large, and others of much smaller displacement. This course had much to recommend it, no doubt, as it brought many accomplished naval architects into competition; but the lack of a continuous and progressive policy has resulted in dissatisfaction and difficulty, and this is frankly acknowledged by French authorities. Two years elapsed after the date when the French resolutely undertook the construction of submarines before the British Admiralty ordered five vessels of the Holland type from Messrs. Vickers, Maxim and Co., who had acquired the concession for the use of the Holland Company's patents. These first vessels in essentials were repetitions of the type which had been tried and officially approved by the authorities of the United States Navy. It was agreed that all improvements made by the Holland Company should be at the service of the British Admiralty through the English *concessionaires*. In this manner the royal navy at once acquired advantages attaching to the long experience and great skill of Mr. Holland; and with that advantage there was associated the possibility of utilizing their own technical resources and those of Messrs. Vickers, Maxim and Co. For five years a continuous policy has been followed in the development of our submarines, all of which have been constructed at Barrow-in-Furness. There has been a great development in size, speed and general efficiency, resulting necessarily in correspondingly greater cost per vessel. Information of an official and authoritative character relating to submarines is freely published in France and the United States, but for British submarines, corresponding official information is scanty. It has for years been the rule to give in the navy estimates full particulars of dimensions and costs for all other classes of British warships; but for submarines a policy of secrecy is adopted that is most unreasonable and unnecessary. From the best sources of information accessible, it appears that the growth in size, with a correspondingly increased cost, has been even more rapid here than in France. Our first five submarines are 63 feet in length, 120 tons in displacement, with gasolene engines of 160 horse-power for surface propulsion, giving a speed of 8 to 9 knots. The electric motors for submerged propulsion are estimated to give a speed of about 7 knots. The contract price for each vessel in the United States was about 34,000*l.*, and that is about the price paid for our earliest vessels. The latest type of which particulars are available are said to be about 150 feet in length, 300 tons in displacement, and with gasolene engines of 850 horse-power for surface propulsion, giving a surface speed of 13 knots and a radius of action of 500 miles. The under-water speed is 9 knots, and the radius of action when submerged about 90 miles. No official particulars have been published as to the contract price for these vessels, which is certainly an undesirable course to adopt, seeing that for other and admittedly sufficient reasons these contracts have not been subject to competition as yet. It may be hoped that the admiralty will reconsider this matter and treat submarines similarly to other vessels.

In French official classification a distinction is made between submarines and submersibles, and this terminology has been the cause of some confusion. Both classes are capable of diving when required, and both can make passages at the surface. In this surface condition a considerable portion of the vessel lies above the water-surface and constitutes what is technically called a 'reserve of buoyancy.' In the submersible this reserve of buoyancy and the accompanying freeboard is greater than in the submarine type, and in this respect lies the chief difference between the two types. The submersible has higher freeboard and greater reserve of buoyancy, which secure better seagoing qualities, and greater habitability. The deck or platform is situated higher above water, and to it the crew can find access in ordinary weather when making passages, and obtain exercise and fresh air. Recent exhaustive trials in France are reported to have established the great superiority of the submersible type when the service contemplated may involve sea passages of considerable length. The French policy, as recently announced, contemplates the construction of submersibles of about 400 tons displacement for such extended services, and proposes to restrict the use of submarines to coast and harbor defence for which vessels of about 100 tons displacement are to be employed. All recent British submarines would be ranked as submersibles according to the French classification, and it is satisfactory to know, as the result of French experiments, that our policy of construction proves to have distinct advantages. In addition to these two types of diving or submarine vessels, the French are once more discussing plans which have been repeatedly put forward and practically applied by M. Goubet, namely, the construction of small portable submarine vessels which could be lifted on board large ships and transported to any desired scene of operations. In the Royal Navy for many years past, it has been the practise to similarly lift and carry second-class torpedo or vedette boats about 20 tons in weight. Lifting appliances for dealing with these heavy boats have been designed and fitted in all our large cruisers and in battleships, and a few ships have been built as 'boatcarriers.' The first of these special depôt ships in the royal navy was the *Vulcan* ordered in 1887–8, the design being in essentials that prepared by the writer at Elswick in 1883. The French have also built a special vessel named the *Foudre* which has been adapted for transporting small submarines to Saigon, and performed the service without difficulty. Whether this development of small portable submarines will take effect or not remains at present an open question, but there will be no mechanical difficulty either in the production of the vessels themselves or in the means for lifting and carrying them. M. Goubet worked out with complete success designs for vessels about 26 feet long and less than 10 tons displacement, with speeds of 5 to 6 knots, the trials of which have been very fully described, but French authorities have not adopted the type, and no decision seems to have been taken to introduce it. In this country no similar action has been taken, and our smallest submarines weighing 120 tons cannot be regarded as 'portable.' Indeed, some leading British authorities on submarines have indicated that experience is adverse to the construction of vessels in which not more than two or three men would form the crew, and on that ground have condemned the construction of these small submarines. They would necessarily be of slow speed and very limited radius of action, while their efficient working would depend upon the nerve and skill of only two or three men working in a very confined space.

Progress in mechanical engineering and in metallurgy has been great since Bushnell constructed and used his first submarine in 1776, during the war between the United States and this country. These advances have made it possible to increase the dimensions, speed and radius of action of submarines; their offensive powers have been enlarged by the use of locomotive torpedoes; and superior optical arrangements have been devised for discovering the position of an enemy while they themselves remain submerged. But it cannot be claimed that any new principle of design has been discovered or applied. From descriptions left on record by Bushnell and still extant, it is certain that he appreciated, and provided for the governing conditions of the design in regard to buoyancy, stability, and control of the depth reached by submarines. Indeed Bushnell showed the way to his successors in nearly all these particulars, and—although alternative methods of fulfilling essential conditions have been introduced and practically tested—in the end Bushnell's plans have in substance been found the best. The laws which govern the flotation of submarines are, of course, identical with those applying to other floating bodies. When they are at rest and in equilibrium they must *displace* a weight of water equal to their own total weight. At the surface they float at a minimum draught and possess in this 'awash' condition a sufficient freeboard and reserve of buoyancy to fit them for propulsion. When submarines are being prepared for 'diving' water is admitted to special tanks, and the additional weight increases immersion and correspondingly reduces reserve of buoyancy. In some small submarines comparative success has been attained in reaching and maintaining any desired depth below the surface simply by the admission of the amount of water required to secure a perfect balance between the weight of the vessel and all she contains, and the weight of water which would fill the cavity occupied by the submarine when submerged. For all practical purposes and within the depths reached by submarines on service water may be regarded as *incompressible;* the submarine should, therefore, rest in equilibrium at any depth if her total weight is exactly balanced by the weight of water displaced. If the weight of the vessel exceeds by ever so small an amount the weight of water displaced, that excess constitutes an accelerating force tending to sink the vessel deeper. On the contrary, if the weight of water displaced exceeds by ever so small an amount the total weight of the vessel, a vertical force is produced tending to restore her to the surface. Under these circumstances, it is obvious that if the admission or expulsion of water from internal tanks (or the extrusion or withdrawal of cylindrical plungers for the purpose of varying the displacement) were the only means of controlling vertical movement, it would be exceedingly difficult to reach or to maintain any desired depth. This difficulty was anticipated on theoretical grounds, and has been verified on service—in some cases, with considerable risks to the experimentalists—the submarines having reached the bottom before the vertical motion could be checked. It has consequently become the rule for all submarines to be left with a small reserve of buoyancy when brought into the diving condition. Submergence is then effected by the action of horizontal rudders controlled by operators within the vessels. Under these conditions, submergence only continues as long as onward motion is maintained, since there is no effective pressure on the rudders when the vessel is at rest. The smallest reserve of buoyancy should always bring a submarine to the surface if her onward motion ceases, and, as a matter of fact, in the diving condition that reserve is extremely small, amounting to only 300 lbs. (equivalent to 30 gallons of water) in vessels of 120 tons total weight. This is, obviously, a narrow margin of safety, and necessitates careful and skilled management on the part of those in charge of submarines. A small change in the density of the water, such as occurs in an estuary or in the lower reaches of a great river, would speedily obliterate the reserve of buoyancy and cause the vessel to sink if water was not expelled from the tanks. Moreover, variations in weight of the submarine (due to the consumption of fuel, the discharge of torpedoes or other causes) must sensibly affect the reserve of buoyancy, and arrangements must be made to compensate for these variations by admitting equal weights of water in positions that will maintain the 'trim' of the vessel. Additional safeguards against foundering have been provided in some submarines by fitting detachable ballast. The more common plan is to make arrangements for rapidly expelling water from the tanks either by means of pumps or by the use of compressed air. In modern submarines, with locomotive torpedoes, compressed air is, of course, a necessity, and can be readily applied in the manner described if it is desired to increase their buoyancy.

The conditions of stability of submarines when diving, are also special. At the surface, owing to their singular form, the longitudinal stability is usually much less than that of ordinary ships. When submerged, their stability is the *same in all directions*, and it is essential that the center of gravity shall be kept below the center of buoyancy. This involves no difficulty, because water-ballast tanks can be readily built in the lower portions of the vessel. Small stability in the longitudinal sense, however, necessitates great care in the maintenance of trim, and in the avoidance of serious movements of weights within the vessels. Moreover, when a vessel is diving under the action of her longitudinal rudders, she is extremely sensitive to changes of trim, and great skill is required on the part of operators in charge of working the rudders. As the under-water speed is increased, the pressure on the rudders for a given angle increases as the *square* of the velocity, and sensitiveness to change of trim becomes greater. This fact makes the adoption of higher under-water speed a matter requiring very serious consideration. Some authorities, who have given great attention to the construction of submarines, have been opposed to the adoption of high speeds under water, because of the danger that vessels when diving quickly may reach much greater depths than are desirable. Causes of disturbance which might be of small importance when the under-water speed is moderate, may have a greatly exaggerated effect when higher speeds are reached. Cases are on record where modern submarines in the hands of skilled crews have accidentally reached the bottom in great depths of water, and have had no easy task to regain the surface. For these reasons, it is probable that while speeds at the surface will be increased, under-water speeds will not grow correspondingly. Indeed, the tactics of submarines hardly appear to require high speed under water, seeing that it is an important element in successful attack to make the final dive at a moderate distance from the enemy. It is authoritatively stated that in our submarines complete control of vertical movements has been secured by means of skilled operators, and that a constant but moderate depth below the surface can be maintained. Proposals have been made and successfully applied to small submarines for automatically regulating the depth of submergence by apparatus similar to that used in locomotive torpedoes. For the larger submarines now used such automatic apparatus does not find favor, and better results are obtained with trained men.

The possibility of descending to considerable depths has to be kept in view when deciding on the form and structural arrangements of submarines, which may be subjected accidentally to very great external pressure. It is absolutely necessary to success that, under the highest pressure likely to be endured, there shall be rigidity of form, as local collapse of even a very limited amount might be accompanied by a diminution in displacement that would exceed the reserve of buoyancy. This condition is not difficult of fulfillment, and the approximately circular form usually adopted for the cross-sections of submarines favors their resistance to external pressure.

Under former conditions, there was difficulty in remaining long under water without serious inconvenience from the impurity of the air. Now, by suitable arrangements and chemical appliances, a supply of pure air can be obtained for considerable periods, sufficient indeed for any operations likely to be undertaken.

The use of gasolene engines for surface propulsion has many advantages. It favors increase in speed and radius of action, and enables submarines to be more independent and self-supporting. Storage batteries can be recharged, air compressed and other auxiliary services performed independently of any 'mother' ship. At the same time, it is desirable to give to each group of submarines a supporting ship, serving as a base and store depôt, and this has been arranged in this country as well as in France. With gasolene engines, care must be taken to secure thorough ventilation and to avoid the formation of explosive mixtures of gas and air, otherwise accidents must follow.

Little information is available as regards the success of 'periscopes' and other optical instruments which have been devised for the purpose of enabling those in command of submarines to obtain information as to their surroundings when submerged. In this department secrecy is obviously desirable, and no one can complain of official reticence. From published accounts of experimental working abroad as well as in this country, it would appear that considerable success has been obtained with these optical instruments in comparatively smooth water. It is also asserted that when the lenses are subjected to thorough washing by wave-water, they remain efficient. On the other hand, the moderate height of the lenses above water must expose them to the danger of being wetted by spray even in a very moderate sea, and experience in torpedo-boats and destroyers places it beyond doubt that the resultant conditions must greatly interfere with efficient vision. In heavier seas, the comparatively small height of the lenses above water must often impose more serious limitations in the use of the periscopes and similar instruments. Improvements are certain to be made as the result of experience with these optical appliances, and we may be sure that in their use officers and men of the Royal Navy will be as expert as any of their rivals. But when all that is possible has been done, it must remain true that increase in offensive power and in immunity from attack obtained by submergence will be accompanied by unavoidable limitations as well as by special risks, resulting from the sacrifice of buoyancy and the great reduction in longitudinal stability which are unavoidable when diving. These considerations have led many persons to favor the construction of so-called *surface-boats* rather than submarines. They would resemble submersibles in many respects, but the power of diving would be surrendered, although they would be so constructed that by admitting water by special tanks they could be deeply immersed and show only a small target above the surface when making an attack. There would be no necessity in such surface vessels to use electric motors and storage batteries, since internal combustion engines could be used under all circumstances. Hence it would be possible without increase of size to construct vessels of greater speed and radius of action and to simplify designs in other important features. It is not possible to predict whether this suggestion to adopt surface-boats rather than submersibles will have a practical result; but it is unquestionable that improvements in or alternatives to internal combustion engines will favor the increase of power in relation to weight, and so will tend to the production of vessels of higher speed. The comparatively slow speed of existing submarines as compared with destroyers and torpedo-boats of ordinary types admittedly involves serious limitations in their chances of successful attack on vessels under way, and higher surface speeds are desirable.

Concurrently with the construction of submarines, experiments have been made in this country and abroad to discover the best means of defence against this method of attack. Here again authentic details are necessarily wanting, since the various naval authorities naturally wish to keep discoveries to themselves. It is very probable, however, that published accounts of tests between swift destroyers, vedette boats and submarines are not altogether inaccurate, and according to these accounts the periscopes of submarines have been found useful by assailants as the means of determining the position of the submarines, and aiding their entanglement. Comparatively limited structural damage to a submarine in the diving condition may be accompanied by an inflow of water in a short period, which will result in the loss of the vessel. The accident to Submarine A 1, which was struck by a passing mail steamer, illustrates this danger. It is reasonable to accept the published reports that large charges of high explosives exploded at a moderate distance may have a serious effect against submarines, and cause them to founder. Their small reserve of buoyancy in the diving condition makes them specially liable to risks of foundering rapidly, and little more than a crevice may practically fill the interior with water in a very short time when the vessel is submerged even to a moderate depth. On the other hand, reports which have appeared of the manœuvres in France and elsewhere, when attacks have been made by submarines on vessels at anchor or under way, show a considerable percentage of successes. Such exercises are valuable no doubt for purposes of training, but under peace conditions it is necessary to avoid the risks of damage to submarines, which might easily become serious if the defence were pressed home as it would be in war. When the officers and crews of submarines know that they will be treated more considerately than in real warfare, they will naturally take chances, and make attacks involving possible destruction under the conditions of a real action. In short, naval manœuvres in this department, while they may be useful in increasing the skill and confidence of officers and men in the management of submarines, can be no real test of fighting efficiency.

Submarines and airships have certain points of resemblance, and proposals have been made repeatedly to associate the two types, or to use airships as a means of protection from submarine attacks. One French inventor seriously suggested that a captive balloon attached to a submarine should be the post of observation from which information should be telephoned to the submarine as to the position of an enemy. He evidently had little trust in periscopes, and overlooked the dangers to which the observers in the car of the balloon would be exposed from an enemy's gun-fire. Quite recently a proposal has been made by M. Santos Dumont to use airships as a defence against submarines: his idea being that a dirigible airship of large dimensions and moving at a considerable height above the surface of the sea, could discover the whereabouts of a submarine, even at some depth below the surface, and could effect its destruction by dropping high explosive charges upon the helpless vessel. Here again, the inventor, in his eagerness to do mischief, has not appreciated adequately the risks which the airship would run if employed in the manner proposed, as submarines are not likely to be used without supporting vessels. Hitherto, submarines themselves have been armed only with torpedoes, but it has been proposed recently to add guns, and this can be done, if desired, in vessels possessing relatively large freeboard. No doubt if gun armaments are introduced, the tendency will be to further increase dimensions and cost, and the decision will be governed by the consideration of the gain in fighting power as compared with increased cost.

Apart from the use of submarine vessels for purposes of war, their adoption as a means of navigation has found favor in many quarters. Jules Verne in his 'Twenty Thousand Leagues under the Sea,' has drawn an attractive picture of what may be possible in this direction, and others have favored the idea of combining the supposed advantages of obtaining buoyancy from bodies floating at some depth below the surface with an airy promenade carried high above water. Not many years ago an eminent naval architect drew a picture of what might be accomplished by utilizing what he described as the 'untroubled water below' in association with the freedom and pure air obtainable on a platform carried high above the waves. These suggestions, however, are not in accord with the accepted theory of wave motion, since they take no note of the great depths to which the disturbance due to wave-motion penetrates the ocean. The problems of stability, incidental to such plans, are also of a character not easily dealt with, and consequently there is but a remote prospect of the use of these singular combinations of submarine and aerial superstructures. There is little likelihood of the displacement of ocean steamships at an early date by either navigable airships or submarines, and the dreams of Jules Verne or Santos Dumont will not be realized until much further advance has been made in the design and construction of the vessels they contemplate.

TRIAL AND ERROR AS A FACTOR IN EVOLUTION

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SINCE Darwin wrote there have been many general formulæ advanced under which all forms of development might be brought, and while each has sufficed for a time, each has been seen to fail and each has been replaced with greater or less completeness when tested by a new set of facts. While no one of the formulæ can be regarded as final, each has been valuable in so far as it has summarized the facts and points of view of the age under which it has developed.

Within the last decade there seem to be facts developing in varying fields that support a new formula, which, while perhaps not so definite in its explanation as many that have preceded it, can at least lay claim to very wide application. This generally stated is that all progress is the result of chance trials and a selection from the trials of those that are successful in attaining some end. The first formulation of the process in so many words seems to have been to describe the method by which animals learn. As Professor Thorndike and many later investigators have shown, an animal learns simply as the result of a selection from his chance movements—those which serve for some definite end. When a horse learns to open a gate or a dog to bring a stick through a fence, learning is accomplished by trying all possibilities until the end desirable at the moment is attained, and after it is once attained there is usually a smaller number of false movements and a shorter time of accomplishment at each succeeding trial, until finally all movements but the right one have been eliminated. These observations make a sufficient number of possible movements and a selecting agent the only essentials in the learning process.

From this comparatively modest starting point the doctrine has extended in both directions. It seems fairly evident from experiments that man must learn new movements in exactly the same way as the animal. He, too, can not be helped to learn by being put through the movement from outside. Knowledge of anatomical relations and rational external knowledge is valueless except as it serves as a point of departure. The only method by which the child or man can acquire new movements is by painfully trying and selecting the movements that most nearly accomplish the end in view.

Recently Professors Jennings and Holmes, in studies of the reactions of relatively low forms of life, seem to show that much that has hitherto been regarded as an almost machine-like response to external stimulation is not made with the definiteness that has been supposed. On the contrary, what seems to take place is a feeling about for a favorable condition. When this is found there is either continued motion in this most favored direction or quiescence in the most favorable position. Here again we should have to do with trial and error, but with less complicated possibility of movement and, in all probability, with a different basis for the selection of the favorable condition.

Still a fourth expansion of the category of trial and error is possible in a metaphorical sense. This is to explain the general course of evolution. If we accept in all strictness the conclusions of Weismann, there is no possibility of foreseeing with very great accuracy any change in a race. Changes of one kind appear here, changes of another kind appear there. Aside from the conditions of mating, however, there is no way of tracing to any known causes the changes observed. We are left then with what, at the present stage of knowledge, seem entirely unforeseen and undetermined chance changes in the animal structure, with an accompanying set of instincts and general activities. The real determining factor is, of course, natural selection. In brief the environment determines which of the many forms and functions that originate by chance shall survive. By personification, and even more literally, we can think of the chance variations as the analogue of the trials of the individual animal, and survival as corresponding to the movement that is successful and so retained.

If we should then be permitted to generalize, we should have chance at the basis of all learning, all advancement, all adaptation. The primary facts would be the variation in structure, which would form the basis for all other adaptation. Within the organism at the lowest stage would be found adaptation from moment to moment on the basis of successful chance adjustment. At this stage, however, there is no learning. One adjustment is of no value for later activities, as the animal is at the same level, in the same condition, after the adaptive movement has been made as it was before. At the next stage, in addition to the increased complexity of the organism which makes possible more numerous movements, there is retention of the successful trials. A movement once made is accompanied by a change in the organism which makes that movement more likely to occur in the future. From this point upward there is variation in degree of complexity of possible movements, in the readiness with which movements once attained are retained and repeated, but there is no great change in the mechanics of the problem.

What does change throughout, and what is, after all, on this theory the essential factor in all development, is the selecting agent and the rewards which serve to make one thing permanent rather than another.

The selecting agent in the race is the environment, and the agent of selection is always life and death. If the organism varies in a way that is suitable, it lives and its progeny multiply. If, on the contrary, some variation be unfavorable, death is its punishment, the animal is eliminated, and nothing further is heard of it in the struggle for existence.

In the earliest forms, in the paramecium, upon which Professor Jennings has worked, or in the blow-fly larva, that Professor Holmes investigated, we can hardly imagine that there is much more than vague chemical activity or quiescence. When the light is favorable, motion directly ahead is preferred, or no motion at all. The animal moves away rather than towards the light when negatively phototactic merely because there is no physico-chemical tendency to draw back the head when it is turned away from the light and there is a stimulus which leads to general locomotion. We have to do with the rudiments of pleasure and pain, perhaps, but we can be sure of nothing more than increased tendency toward motion in one position and decreased tendency to movement in the other. It is approximately a mechanical equivalent of pleasure and pain.

At the next level of complexity in animal learning, the case is not so different. The simplest answer to the question is that the creature is controlled by pleasure and pain. It is not as clear as might be imagined at first sight what this means in last analysis, for, at the very lowest, pain and pleasure must go for their ultimate explanation to the evolution of the species. Other factors are perhaps to be found in the earlier experience of the animal and in even more remote circumstances. While we can not unravel the tangle of factors involved in what we call pleasure and pain, yet it may be interesting to indicate that, regarded as a selecting agent, neither is a simple thing but the result of many factors. It is at least worth while to indicate that the deciding factors here are conscious, as opposed to the chemical or physical processes in the organism or to the natural forces in the environment. There may be nothing really new or peculiar in the circumstances or conditions, but it does mean that we classify the manifestations under a new head. This alone makes it worth while to set the selecting agent off as belonging to a special class or group.

If we bring the different groups under a single general statement, we should have racial progress, due to the chance variations in the animal structures, and have as the selecting agent the environment, which enforces its decrees through the life or death of the organism, or, at least through its flourishing or its failure to flourish. The adaptation of the individual would take place in the lower forms through chance responses to stimulation, which were in the main not determined by the nature of the stimulus, but which attained their end by a selection in terms of the chemical constitution of the organism. Each adaptation here is without influence upon later reactions, but each must be hit upon anew each time the circumstances arise. There is no learning. At the next stage again the response is brought about by chance. and the selection determines the process in its completeness, but there is here, on the one hand, a conscious pleasure and pain, and what is more certain and more important as an objective criterion, there is a permanent effect left upon the organism by the action once performed.

In man and perhaps in some of the higher animals the same general processes hold, but in addition to immediate organic processes of pleasure and pain there are new elements added to the selecting agencies. which may ultimately become pleasure and pain. but are only remotely organic in their origin. These in some way all seem to originate in the social *milieu*. all seem to have their origin in the phenomena connected with the living of man in groups. There are many things which seem indifferent to racial survival or to immediate pleasure and pain that will always and at once be repressed in terms of good manners or good form. Some traditional virtues strike one who has been reared in a given society as just as fundamental as others which can be shown to possess survival values. but we find civilizations of high rank which survive just as well without them. So, if an Anglo-Saxon were to select the fundamental virtues, modesty would be one of them. But let him consider for a moment the customs of the Japanese. and their national success, and then modesty would not seem so fundamental as it did at first sight.

These more subtle selecting agents act in the same way as the cruder. When any individual by chance departs from the traditional line of conduct. he is at times made to feel by popular attitude that he himself or his conduct is not welcome. It is not merely departure from the social norm that is repressed. but departure in certain ways that can not be foretold in advance of trial. Some innovations are welcomed and accepted and the discoverer made a social hero. exceptional man or genius. Others are checked in one or more of the insidious ways that in society are more effective than the arm of law. What determines this social selection. however. is not evident. In extremes it may be racial survival. in minor cases it may be what passes for esthetic appreciation. although esthetic appreciation can probably be reduced to social selection as well as social selection to esthetic appreciation.

One thing seems fairly evident. and this is that imitation does not play the important part in social selection or in any form of learning that has been supposed. In these higher forms. what we want explained is not the persistence of the traditional conduct. but the determining factors in selecting some and eliminating other departures from the traditional methods of action. Even in the learning of children or of animals, the striking feature of the process is not the fact that the child gradually approaches the standard of society, but the method by which the approach is brought about. If you study a child learning to speak, it will at once be seen that there is no inherent impulse to repeat the sounds that are spoken, but that all sorts of movements are made, and those which in themselves are interesting or acquire vicarious interest from their resemblance to the sounds about are repeated until learned. The child does not imitate everything, although from the indifference of his interests he sometimes seems to. His imitation is not from a desire to reach an end; rather the child selects from the spontaneous unforeseen movements of all kinds those which strike his fancy. In spite of the fact, then, that there seems to be no instinct in the German child to speak German rather than English, he nevertheless selects from his varying movements those which resemble the sounds that he hears and so he learns to speak German. The sounds heard about him are by no means the incentive to the endeavor. Experiments seem to indicate that even in adults a knowledge of what it expected, or even a desire to execute a certain movement when one has exact anatomical knowledge of the parts to be moved, is no aid to its accomplishment in advance of trial. Much less then can we assume that the unappreciated presence of a sound can spur to its production by the child. The instincts that may serve to produce the sounds from which selection is made are varied and are the expression of numerous connecting paths in the nervous system. There is no evidence of an instinct or impulse to imitate for the sake of imitation.

The explanation of the numerous actions that are imitated by the child is to be found, on the one hand, in the great variety of useless movements at his command, and on the other in the wide range of his interests as yet unrestricted by the training that tends to restrain the adult individual in one relatively narrow line.

Imitation, then, seems to be a subordinate form of the general law of learning rather than learning a subordinate form of imitation. The explanation of learning that depends upon trial and error alone differs from an explanation in terms of imitation merely in that it makes individual appreciation of the results of a movement the essential element rather than the presence of a similar movement in some of the individual's neighbors. The two theories are alike in that the former must insist that seeing a fellow perform the movement is an important factor in raising individual appreciation. But they must differ in that it as firmly denies that seeing a movement performed is any incentive to its performance by the second individual. A movement seen may become interesting if the organism chances to throw out a similar movement immediately after the first has been observed, but it will serve merely to make the individual repeat it a second time when once it has been made by chance; it will not serve to initiate a movement of itself.

The social factors which have been brought under the general term imitation have much the same relation to the more complicated conduct of the affairs of life that the simple copy has in spurring to the more simple and immediate action. They do not primarily initiate but serve to select factors otherwise initiated. Good form may lead to conscious imitation in an adult who already has command over the movement. Fashion may directly bring about imitation in the matters of dress, where the movements are already under control and mental processes alone are involved in the choice, but the impelling forces in society are those that make a man shunned who offends, and give him renewed applause when he initiates valuable lines of action. The enforcement of the moral law, apart from the material agencies, depends not upon precept or good example, but upon these vague social forces that are constantly repressing some and rewarding other departures from the accepted standards. Some of those rejected are rationally and by association apparently no worse than those retained. But social selection is none the less definite and absolute in fact because it seems irrational when attempt is made to explain it theoretically. The man who departs from the traditional course takes his reputation in his hands, for society is essentially conservative. Chances are that the result will be social death, and reasonably so, because the long course of evolution would probably make the existing the best, when we are dealing with any course of conduct that can have any survival value. Were it possible to reduce all the influences of social control to immediate or traditional survival values, the problem would be very much simpler than is really the case. Many courses of action which society represses most rigidly are apparently indifferent to survival, and many can not easily be shown to be associated with lines of action that could have been of value at present or at any earlier period.

The nature of the action selected will vary from civilization to civilization and from people to people and even from community to community within the same civilization. It does not seem possible as yet to push very far in the analysis of these elements, but it is nevertheless valuable to recognize their importance for both individual and sociological psychology. An insistence upon the importance of this factor under the term imitation or what else has probably been the most important contribution that psychological sociology has made, and an analysis into its elements and tracing it back to causes would undoubtedly have even more important results.

Looking back upon our general summary of this modern formulation of development as a whole we may ask what its value may be. The chief importance lies in the fact that it permits one to bring the generally accepted facts of racial and individual development under a single phrase. Even though the words are used in a slightly different sense, it is evident that chance gives the variations upon which all development must be based, even though the factors that we must assume to bring about the chance result are not altogether the same in the racial as in the individual development. The process of selection is also much the same throughout, for selection results from mere survival of one and rejection of others.

The main lack in the formula is our inability at present to analyze or define all the selecting agents. The environment in general which serves as the agent in racial development is comparatively well understood, or at least the meaning of the word and the methods of producing results give definite pictures. On the other hand, the physico-chemical constitution of the organism which must be assumed in the lowest organisms, and the intimate nature of social pressure which is effective in man both need much more complete analysis. And even pleasure and pain are not as simple or as free from ambiguity as we are inclined to suppose at first sight. But at least each of them marks a fairly definite field for investigation and will serve in so far to satisfy the needs of a formulation of the facts already known, and act as a spur to further work.

THE PROGRESS OF SCIENCE

THE REWARDS OF SCIENTIFIC RESEARCH

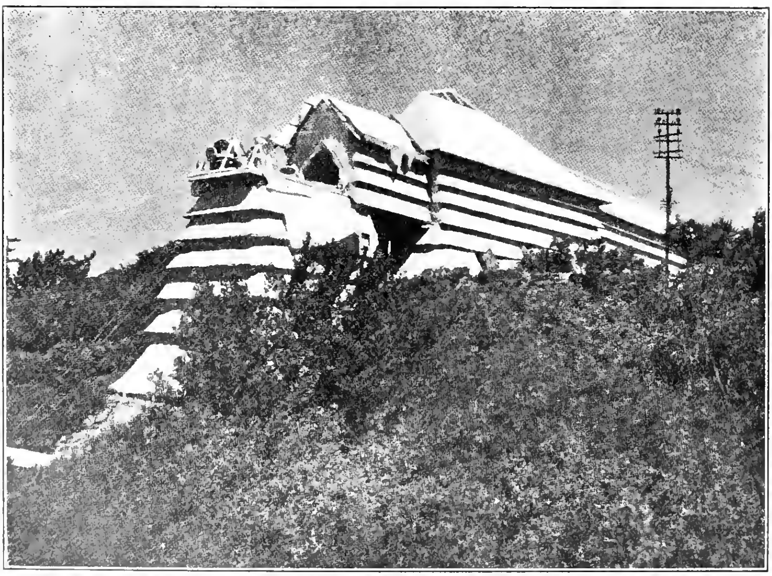
Our economic system rests on the free exchange of services. A state of society may some day be reached in which each will aim to give as much as he can and to take as little, but at present it appeals to our sense of fairness that each should ask for his services what someone else is willing to pay. In the increasing complexity of our society this method is working two serious injustices. One of these is the formation of monopolies. Thanks chiefly to the applications of science, many services can now be supplied at a cost less than people would be willing to pay. When free competition is excluded, either by the conditions of the case or by ingenious combination, people may be made to pay more than a fair return for certain services. The problems of monopoly are being discussed on all sides and remedies are being sought in all directions; but the injustice, which in a way is the converse of monopoly, has scarcely been noticed. This is the case in which an individual gives services without an adequate return, owing to the fact that they are not rendered to a single individual or group who will pay for them, but to society as a whole. A surgeon may ask for an operation for appendicitis as large a fee as his patient is willing to pay, but should he after years of research discover a method of preventing appendicitis altogether, he would receive no payment at all, but would, on the contrary, give up all future fees for the operation. The surgeons who by risking and sacrificing their lives discovered how to suppress yellow fever have received no return for their great services.

This state of affairs not only does injustice to the unrewarded individual, but works immeasurable harm to society—a greater injury probably than all existing monopolies. There are more than a hundred thousand physicians in the United States who are practising on their patients for fees, while there are scarcely five hundred who are studying seriously the causes of disease and the methods of preventing it. The conditions are similar in law and in all professions and trades. The scientific investigator is usually an amateur. He has wealth or earns his living by some profession, and incidentally does what he can to advance science for love of the work. This has its good side in producing a small group of men who are not subject to purely commercial standards. But this is after all a minor factor, and the scientific man is likely to look for fame, which is scarcely more ideal than money and can be supplied to but few. Satisfaction in the work itself is the best reward for work; but no one can know that his work is of value except by the reflected appreciation of others, and in the existing social order the simplest and probably the most adequate expression of this appreciation is direct payment for the service rendered.

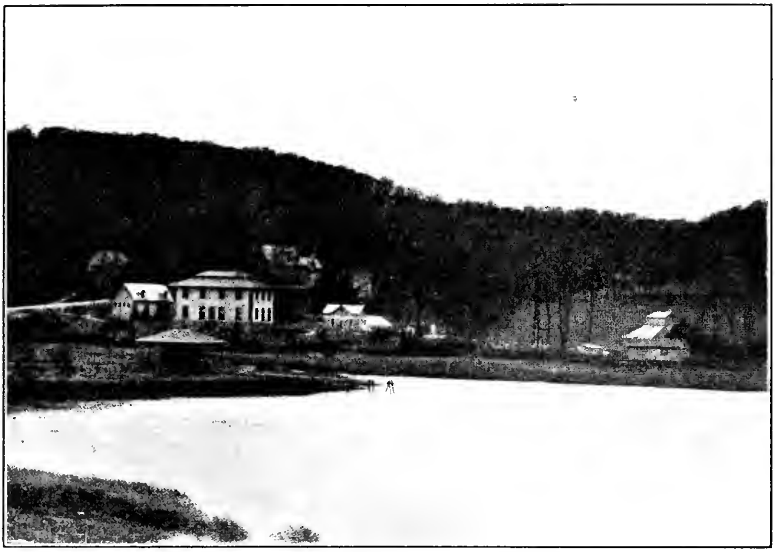
The methods that society has devised to meet this situation, apart from the conferring of honors and fame, are recent and inadequate. Copyrights and patents are the most direct acknowledgment of property in ideas. They have accomplished a good deal, and their scope should be extended. At present only a small part of discovery is covered by the patent office, and this perhaps not the part requiring the greatest genius. It is, however, leading, especially in Germany, to the development of discovery on a sound commercial basis. It is said that one chemical firm employs three hundred doctors of philosophy to carry on scientific investigations. Research has hitherto been forwarded mainly by the universities, where again Germany has led the way. The professorship is given as a reward for successful investigations, and the holder of a chair is expected to devote himself to investigation as well as to teaching. There is a tendency to permit certain professors to engage almost exclusively in research. Thus the astronomical observatories of Harvard, Chicago and California universities are purely research institutions. A further step has been taken in the endowment of institutions, such as the Carnegie Institution and the Rockefeller Institute, explicitly for research. The most logical and important advance, however, consists in the direct conduct of research by the government. As the government should control monopolies, so it should conduct the work which is not for the benefit of a single individual, but for the people as a whole. There are of course no end of difficulties in the control of monopolies or the conduct of research by a municipality, state or nation; but it is exactly these difficulties that it is our business to overcome. And we may congratulate ourselves that our national government is at present accomplishing more for research and the applications of science than the government of any other nation.

THE WORK OF THE CARNEGIE INSTITUTION

The most important private foundation for the promotion of research is the Carnegie Institution of Washington, established four years ago by Mr. Andrew Carnegie with an endowment yielding an annual income of $500,000. The fourth year book, which has been recently issued, is of special interest as it is the first under the presidency of Dr. R. S. Woodward. The work of the year indeed was mainly fixed before the president entered on his office, but in his report to the trustees he gives some indications of the policy that he will recommend. He favors large projects carried on under the auspices

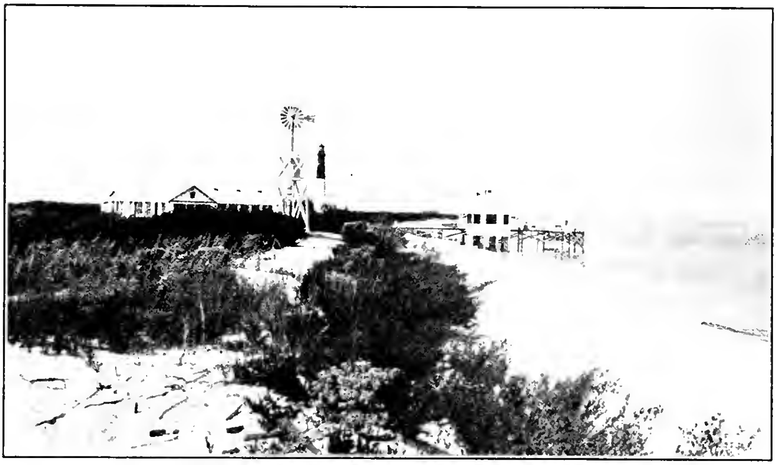


South End of Snow Telescope House, Solar Observatory, Mount Wilson.



GROUNDS AND BUILDINGS OF THE STATION FOR EXPERIMENTAL EVOLUTION AT COLD SPRING HARBOR.

of the institution rather than smaller grants made to individuals in other institutions. Astronomy, geophysics and terrestrial magnetism have been especially favored in the past, and this policy will apparently be continued, as the two specific recommendations made by the president are an astronomical observatory in the southern hemisphere and a laboratory for geophysical research. He says that it seems best "to follow lines of least resistance, promoting chiefly those departments of research which promise sure returns, while seeking at all times to raise the less highly developed to the level of the more highly developed sciences."



LABORATORY BUILDINGS AT TORTUGAS, FROM THE NORTH, SHOWING THE DOCK AND AQUARIUM.

This is a safe policy. The original deed of gift and the act of incorporation leave more to the imagination, and many men of science had dreams of an institution that would become the chief center of scientific organization and inspiration for the country. But it is not fair to expect the impossible, and we should perhaps be satisfied if the institution conducts a geophysical laboratory as efficiently as it would be conducted under the Geological Survey and an astronomical observatory on Mt. Wilson doing as good work as that on Mt. Hamilton.

The large projects received, last year, grants as follows:

Station for Experimental Evolution	$ 12,000
Tortugas Marine Biological Laboratory	15,700
Desert Botanical Laboratory	6,000
Horticulture	10,000
Economics and sociology	30,000
Terrestrial magnetism	25,000
Historical research	14,000
Solar observatory	150,000
Geophysical research	24,000
Nutrition	16,000
Paleontology (transferred to minor grants)	1,800
Total	$304,500

The minor grants amounted to $130,625, including $26,000 to Professor R. Pumpelly for work in archeology and $10,000 for the conduct of the 'Index Medicus.' The following general appropriations have been made for the current year:

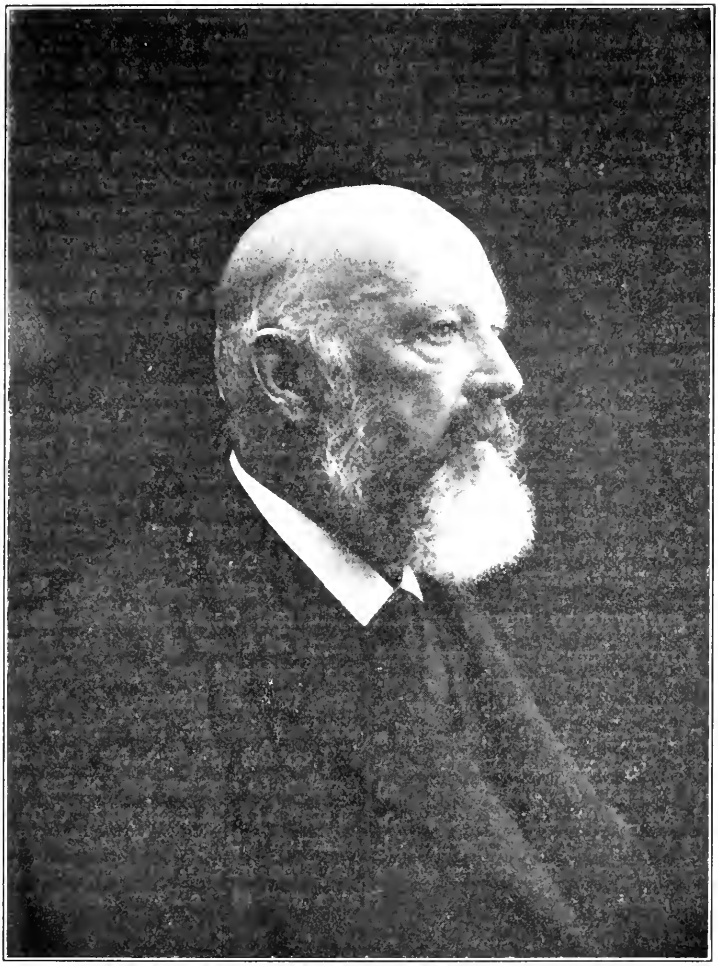
Publication fund to be continuously available	$ 50,000
Administration	50,000
Grants for departments and large projects	552,600
Grants for miscellaneous researches, including grants previously implied	134,000
Total	$786,600

No official announcement has been made of the new work that will be undertaken by the institution, but it may be assumed from the recommendations in the report of the president that the larger part of the appropriation for departments will go to the solar observatory on Mt. Wilson, an astronomical observatory in the southern hemisphere and a geophysical laboratory in Washington. It appears further that a department of botanical research has been established and placed under the direction of Dr. D. T. MacDougal.

An establishment such as the Carnegie Institution is face to face with many new and difficult problems. We regret that means have not been found to make the organization more truly democratic and representative of the scientific men of the country; we regret that its great resources have not been more directly applied to what it only could do. But whatever criticism may be directed against the institution, men of science will agree that the conduct of its work could not be in abler and safer hands than President Woodward's.

PROFESSOR ADOLF VON BAEYER

We noted here recently the award of the Nobel prize in chemistry to Professor von Baeyer. The students and friends of the great German chemist have now published his collected works in celebration of his seventieth birthday, and thanks to the charming autobiographical sketch that is prefaced to the volumes we are able to give some facts in regard to his life and work, together with a portrait. Baeyer was born in Berlin, October 31, 1835, a member of the scientific and literary aristocracy of Germany. His father was an eminent geodesist, his mother's father, J. E. Hitzig, and his uncle, Franz Kugler, were at the center of the literary life of the city, and he had every advantage in the way of association and education. He began systematic chemical experiments at the age of nine and made a discovery of some importance at the age of twelve. While a school boy he made botanical excursions with Paul Ascherson, now professor of botany at Berlin, and extended explorations with Ferdinand von Richthofen, afterwards famous as a geographer. After three semesters at Berlin, Baeyer went to Heidelberg, where Bunsen's laboratory was the chief center of chemical research in Germany. Here he gained much from



Professor Adolf von Baeyer.

a large group of men active in research, especially from Kekulé, and began the investigations in organic chemistry which have made him eminent. It seems desirable to call attention to the great advantages that Baeyer had, which are paralleled in the lives of many other eminent men, because we need at the present time to learn how far scientific achievement is due to inborn genius and how far to favorable circumstances. It is quite possible that the dearth of distinguished men in the United States is less due to lack of natural ability than to the fact that fifty years ago the environment here was but rarely so favorable as in Germany, France or Great Britain.

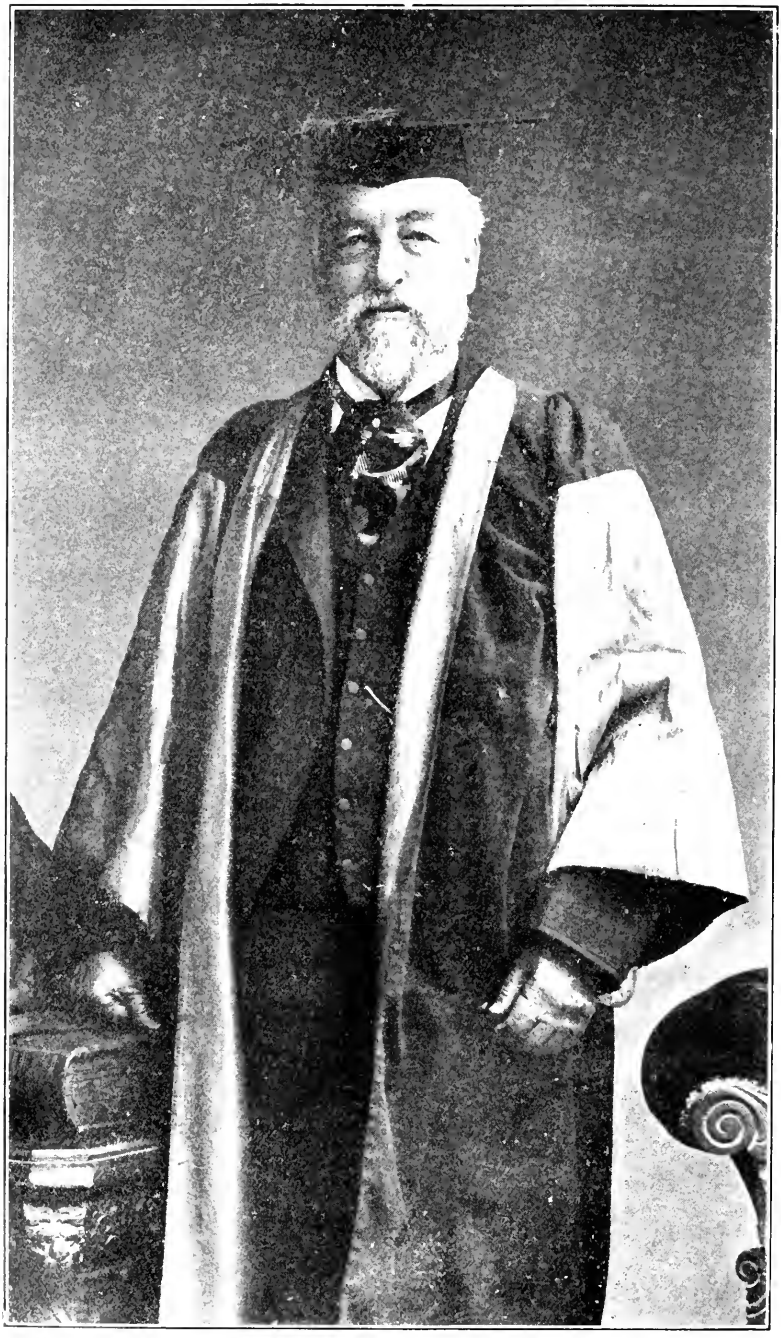
Baeyer's fortunate career has continued to the present time. He followed Kekulé to Geneva but soon qualified as a docent in Berlin with a research on uric acid. His promotion at Berlin was slow, but he developed an important laboratory in connection with the Gewerbeakademie, where he had as students and assistants Liebermann, Graebe and Victor Meyer, and continued his work on the synthesis of organic compounds. He was called to the chair of chemistry in the newly-organized university of Strassburg in 1872, where he had as students Emil and Otto Fischer, and three years later went to Munich as Liebig's successor. Liebig, who established the first chemical laboratory, had gone to Munich on the condition that he should do no laboratory teaching, and it remained for Baeyer to build up a university laboratory. Here he with his pupils and assistants has since continued to carry forward important researches in organic chemistry. His most important work, however, was the artificial production of indigo, accomplished in 1870, and made commercially possible in 1880. This has given Germany a new and important industry. It is a fine example of the interdependence of pure and applied science.

SCIENTIFIC ITEMS

THE German emperor has conferred on Professor Simon Newcomb, the eminent astronomer, the order 'pour le mérite' in science and the arts.—At a meeting of the Royal Astronomical Society, on February 9, Ambassador Reid received the gold medal for 1905, conferred by the society on Professor William Wallace Campbell, director of the Lick Observatory.

IT is planned to present to the city of Philadelphia a statue of Dr. Joseph Leidy, to be erected in the City Hall Plaza. Dr. Leidy, who was born in that city in 1823 and died there in 1891, added much to its scientific eminence, and as president of the Academy of Natural Sciences, professor of human and comparative anatomy and zoology in the University of Pennsylvania, and president of the Wagner Free Institute of Science, accomplished much for these institutions.

THE U. S. government has commissioned President David Starr Jordan, of Stanford University, and Professor Charles H. Gilbert, head of the department of zoology, to conduct an investigation of the fish and fisheries of Japan and the Island of Sakhalin during the coming summer.—Dr. Otto Nordenskjöld and Capt. Mikkelsen were the guests of honor at a dinner given by the Arctic and Explorer's Clubs in New York City, on February 7. It was announced that Dr. Nordenskjöld would sail on the 8th inst. for his home in Sweden, to arrange for another voyage in search of the south pole. Capt. Mikkelsen is getting ready an expedition to the Beaufort Sea, an unexplored Arctic area west of the Parry archipelago.



SAMUEL PIERPONT LANGLEY,

Late Secretary of the Smithsonian Institution

THE POPULAR SCIENCE MONTHLY

APRIL, 1906

THE QUEEN ANT AS A PSYCHOLOGICAL STUDY

BY DR. WILLIAM MORTON WHEELER,

AMERICAN MUSEUM OF NATURAL HISTORY

OBSERVERS of ant behavior have almost invariably fixed their attention on the easily procurable workers, to the all but complete neglect of the males and queens. In the case of the males, this neglect is, perhaps, pardonable, for the behavior of this sex is extremely monotonous. The neglect of the queens, however, as I shall endeavor to show, has not only left untouched a very interesting subject of study, but is responsible for much useless speculation.

Mention of the queen ant unfortunately suggests by association the idea of the queen honey-bee. These two insects are, however, in certain very important respects diametrical opposites. The queen honey-bee is a degenerate creature, unable to nourish herself or her young, to visit the flowers, build or store the comb; while the worker bee, apart from her normal infertility, still retains intact all the true female attributes of the ancestral solitary bees. In ants the very reverse of this is true: the queen is the perfect exemplar and embodiment of the species and has lost none of the primitive female attributes of independence and initiative, which she shares with the female bumble bees, solitary and social wasps. The worker ant, on the contrary, bears all the stigmata of incomplete and retarded development. Although these differences between the queen honey-bee and queen ant and between the respective workers must be apparent to the most superficial observer, yet the familiar conception of the queen honey-bee as little more than an egg-laying machine, so degenerate that she can not exist apart from the workers, has been tacitly expanded to embrace the queen ant. Surely it is time that the reputation of this insect should be viewed in a more favorable light.

Let us follow as briefly as possible the eventful life history of the queen ant. After more protracted larval and pupal stages than those of the worker and male—more protracted in order that she may store up more food and hence more energy in her body—she hatches as a sensitive callow in a colony at the height of its annual development. In other words, she is born into a community teeming with queens, workers and males, and the larvæ and pupæ of these various forms at the season of their greatest activity and growth. From all sides a shower of stimuli must be constantly raining in upon her delicate organization as she tarries for days or even weeks in the dark galleries of the parental

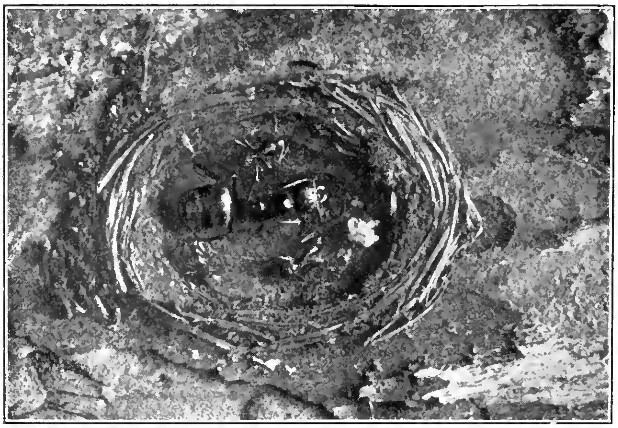


FIG. 1. INCIPIENT COLONY OF CARPENTER ANT (*Camponotus pennsylvanicus*), consisting of the queen, three minim workers and a packet of young larvæ, inhabiting the abandoned pupa case of a beetle (*Rhagium lineatum*) under pine bark. About natural size.

nest, while her color gradually deepens and her integument acquires its mature consistency. During this her prenuptial life, she may assist the workers in carrying about, feeding and cleaning the brood. She eats independently of the food brought into the nest by the foraging workers. She may occasionally join the workers in excavating chambers and galleries. If she belongs to a slave-making species she may even accompany the workers on their cocoon-robbing expeditions. Although she shows that she is able to perform all these actions supposed to be peculiar to the workers, she often does so with a certain desultory incoherency.

When fully mature she becomes impatient for her marriage flight and must often be forcibly detained in the nest by the workers till the propitious hour arrives when the males and females from all the nests in the neighborhood rise high into the air and celebrate their nuptials.

Then the fertilized queen descends to the earth and at once divests herself of her wings, either by pulling them off with her legs and jaws or by rubbing them off against the grass-blades, pebbles or soil. This act of deälation is the signal for important physiological and psychological changes. She is now an isolated being, henceforth restricted to a purely terrestrial existence, and has gone back to the ancestral level of the solitary female Hymenopteron. During her life in the parental nest she stored her body with food in the form of masses of fat and bulky wing-muscles. With this physiological endowment and with an elaborate inherited disposition, ordinarily called instinct, she sets out alone to create a colony out of her own substance. She begins by excavating a small burrow, either in the open soil, under some stone or in rotten wood. She enlarges the blind end of the burrow to form a small chamber and then completely closes the opening to the outside world. The labor of excavating often wears away all her mandibular teeth, rubs the hairs from her body and mars her burnished or sculptured armor, thus producing a number of mutilations, which, though occurring generation after generation in species that nest in hard, stony soil, are, of course, never inherited. In the cloistered seclusion of her chamber the queen now passes days, weeks, or even months, waiting for the eggs to mature in her ovaries. When these eggs have reached their full volume at the expense of her fat-body and degenerating wing-muscles, they are fertilized with a few of the many thousand spermatozoa stored up in her spermatheca and laid. The queen nurses them in a little packet till they hatch as minute larvæ. These she feeds with salivary secretion derived by metabolism from the same source as the eggs, namely, from her fat-body and wing-muscles. The larvæ grow slowly, pupate prematurely and hatch as unusually small but otherwise normal workers. In some species it takes fully ten months to bring such a brood of minim workers to maturity, and during all this time the queen takes no nourishment, but merely draws on her reserve tissues. As soon as the workers mature, they break through the soil and thereby make an entrance to the nest and establish a communication with the outside world. They enlarge the original chamber and continue the excavation in the form of galleries. They go forth in search of food and share it with their exhausted mother, who now exhibits a further and final change in her behavior. She becomes so exceedingly timid

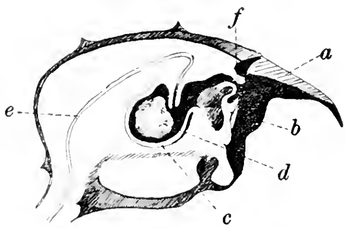


FIG. 2. HEAD OF A RECENTLY FERTILIZED QUEEN OF *Atta sexdens* LONGITUDINALLY BISECTED; *a*, mandible; *b*, labium retracted; *c*, buccal pocket, containing *d*, the pellet of fungus hyphæ carried from the parental nest, *e*, œsophagus, *f*, oral orifice. (After J. Huber.)

FIG. 3 EGGS AND FUNGUS GARDEN IN CELL OF QUEEN *Atta sexdens* FORTY-EIGHT HOURS AFTER THE NUPTIAL FLIGHT. (After J. Huber.)

FIG. 4. EGGS AND FUNGUS GARDEN IN CELL OF QUEEN *Atta sexdens* SEVENTY-TWO HOURS AFTER THE NUPTIAL FLIGHT. (After J. Huber.)

and sensitive to the light that she hastens to conceal herself on the slightest disturbance to the nest. She becomes utterly indifferent to the young, leaving them entirely to the care of the workers, while she limits her activities to laying eggs and imbibing liquid food from the tongues of her attendants. This copious nourishment soon restores her depleted fat-body, but her disappearing wing-muscles have left her thoracic cavity hollow and filled with gases which cause her to float when placed in water. With this circumscribed activity she lives on, sometimes to an age of fifteen years, as a mere egg-laying machine. The current reputation of the ant queen is derived from such old, abraded, toothless, timorous queens found in well-established colonies. But it is neither chivalrous nor scientific to dwell exclusively on the limitations of these decrepit beldames without calling to mind the charms and self-sacrifices of their younger days.

FIG. 5. SILHOUETTE OF A QUEEN *Atta sexdens* IN THE ACT OF MANURING HER FUNGUS GARDEN. A tuft of fungus mycelium is torn out of the garden, placed against the anus and saturated with a drop of fecal liquid. (From an instantaneous photograph, after J. Huber.)

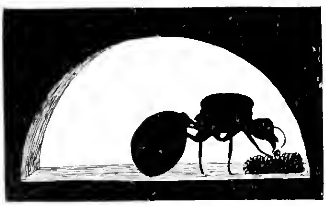


FIG. 6. SILHOUETTE OF A QUEEN *Atta sexdens* REPLACING THE SATURATED TUFT OF MYCELIUM IN THE FUNGUS GARDEN. (From an instantaneous photograph, after J. Huber.)

Now to bring up a family of even very small children without eating anything and entirely on substances abstracted from one's own tissues is no trivial undertaking. Of the many thousands of ant queens annually impelled to enter on this ultra-strenuous life, very few survive to become mothers of colonies. The vast majority, after starting their shallow burrows, perish through excessive drought, moisture or cold, the attacks of parasitic fungi or subterranean insects, or start out with an inadequate supply of food-tissue in the first place. Only the very best endowed individuals live to preserve the species from extinction. I know of no better example of natural selection through the survival of the fittest.

It is certain that the colonies of most species are founded in the manner here described. It is certain, moreover, that all this is rendered possible by the nutritive endowment of the queen. As the winged germ of the species she has all the advantages that a yolk-laden has over a comparatively yolkless egg. Now among the 5,000 known species of ants we should expect to find considerable differences in the quantity of nutriment stored up in the young queen. And this is unquestionably the case. In some species the queens are of enormous size, in others they are very small compared with the workers. And since queens of

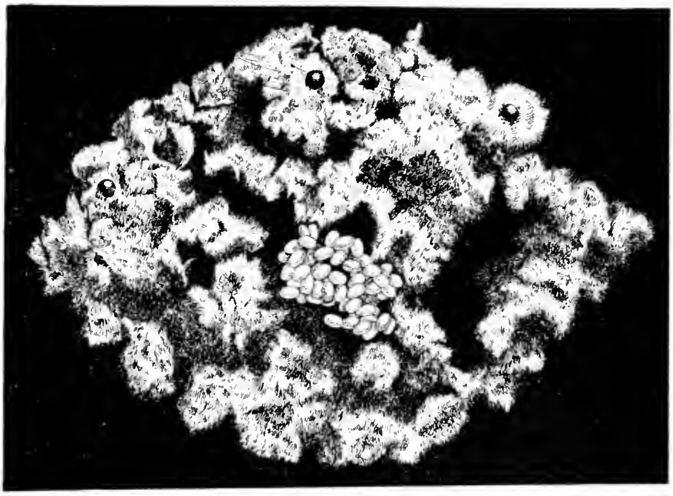


FIG. 7. FUNGUS GARDEN OF *Atta sexdens* FOURTEEN DAYS AFTER THE NUPTIAL FLIGHT. There are about 100 eggs which the queen has placed in a depression in the middle of the garden. Near the periphery there are three drops of the fecal liquid with which the queen manures the garden. (After J. Huber.)

average dimensions are able to start colonies by themselves alone, we should expect that unusually large queens would be able to accomplish even more, and very small queens less. This, too, is borne out by observation.

Unusually large queens are found in the genus *Atta*, a group of American ants that raise fungi for food, and are, so far as known, quite unable to subsist on anything else. The female *Atta* on leaving the parental nest, is so well endowed with food-tissue, that she not only can raise a brood of workers without taking nourishment, but has energy to spare for the cultivation of a kitchen garden. She carries the germ of this garden from the parental nest in the form of a pellet of fungus hyphæ stowed away in her buccal pocket, spits it out soon after completing her chamber, manures with her excreta the rapidly growing hyphæ and carefully weeds them till her firstling brood of workers hatches. These then bring into the nest the pieces of leaves and the vegetable detritus essential to the maintenance and growth of the garden. The extraordinary habits of one of these fungus-raising ants, *Atta sexdens,* have been recently studied in great detail by Jakob Huber, from whose valuable paper I borrow a number of the accompanying illustrations (Figs. 2 to 7).

Very different is the condition of certain queen ants poorly endowed with food-tissue—especially of some whose bodies are actually smaller than the largest workers of their species. Such queens are quite unable to bring up colonies unaided. They are therefore compelled, after fertilization, to associate themselves with adult workers either of their own or of a closely allied species. In the former case the queens may either remain in the parental nest and omit the nuptial flight, or return to the parental or to some other colony of the same species. In either case they add to the reproductive energy of an already established colony and thus prolong its life. If one of these poorly endowed queens, however, happens to alight from her nuptial journey far from any colony of her own species, she is obliged to associate with alien workers. And in this case, according to the species to which she belongs, one of three courses is open to her.

First, she may secure adoption in a small queenless colony of an allied species. Here she is fed, lays her eggs and the resulting larvæ are reared by the strange workers. Eventually the alien workers die off and leave the queen and her own workers as an independent and sufficiently established colony, capable of rapid and often enormous multiplication. This is temporary social parasitism, first observed by myself in some of our American ants, but since found in some of the European species where I predicted its occurrence.

Second, the poorly endowed queen may establish herself in a colony of another species, but be unable, even after her workers have matured, to survive the death of the host colony, except, perhaps, by migrating to another nest of the same species. This is permanent social parasitism.

Third, the queen may enter a small colony of alien workers, and, when attacked, massacre them, appropriate their larvæ and pupæ, carefully secrete and nurse them till they hatch and thus surround herself with a colony of young and loyal workers that can bring up her brood for her without any drain on her food-tissues. This is the method of colony formation adopted by queens of the slave-making ants, as I have found by a number of experiments during the past summer. These queens thus manifest an instinct, hitherto supposed to be exclusively peculiar to the workers, namely the instinct to rob the larvæ and pupæ of another species and bring them up as auxiliaries, or slaves.

Although the foregoing facts belong to ethology rather than to comparative psychology, it seemed necessary to review them before emphasizing their bearing on certain general questions. The behavior of the queen ant may be said to depend, first, on a relatively fixed inherited predisposition, or instinct; second, on inherited plasticity or adaptability; third, on constantly changing physiological states, and fourth, on stimuli which are partly primary and external and partly secondary, internal or true stimuli. These last are probably identical, as suggested by Jennings and others, with the physiological states, which in turn are evidently to be conceived as metabolic processes. That the queen ant profits by her prenuptial sojourn in the parental nest to learn by experience, tradition and imitation, I have no doubt, but queens hatched in isolation show that this acquisition is insignificant in comparison with the inherited instincts. These appear as elaborate catenary reflexes, of which the reactions to light and contact stimuli may be taken as examples. In her callow stages the queen is negatively phototropic and positively stereotropic, but as the time for her nuptial flight approaches, these reactions are reversed, so that she seeks the light and avoids contact with the walls of the nest. After fertilization she again returns to the prenuptial condition—she shuns the light and tries to bury herself in the soil or under stones. These reactions, first described by Loeb, are as irresistible as they are adaptive. It can be shown, moreover, that these changes in tropisms are accompanied by changes in other instincts. My attention was first directed to the stereotyped character of these reactions in the queen ant by a simple experiment. I found that merely pulling off the wings with the tweezers caused the insect to pass at once from positive phototropism and negative stereotropism to the reverse. This shows that the change is not caused by fecundation, since artificially deälated virgin queens went through the complex catenary reflex of founding a colony with the same precision as fertilized individuals.

These and other observations, which I am unable to give in the space at my disposal, all point to constantly changing metabolic states as the mainspring of the queen ant's behavior. She is, in fact, a veritable chemical laboratory, in which we can see more clearly than in many other animals, a direct relation between behavior and the flux of metabolism.

I hasten over this matter to another general problem. The discovery that the queen ant really possesses, at least *in potentiâ*, all the instincts of the worker, besides others peculiar to herself, puts a different construction on a matter which has long been puzzling theoretical zoologists. It has been taken for granted that worker ants are necessarily sterile and that they possess morphological, physiological and psychological characters not represented in the queens of their species. On such assumptions it is, of course, impossible to understand how the workers can have come by the obviously adaptive and exquisitely correlated characters, which they are unable to transmit. It will be remembered that neo-Darwinians and neo-Lamarckians, in the persons of Weismann and Herbert Spencer, locked horns over this matter some years ago. Both in this and in many similar discussions, the very premises which both parties accepted are unwarranted. In the first place, it is now known that workers readily become fertile when well fed and that they can and often do produce normal young from unfecundated eggs. Although these young are usually, if not always, males, it is evident that these males, through the eggs which they fertilize, can transmit the characters of their worker mothers to succeeding generations of queens and workers. Thus the congenital, and perhaps even the acquired, characters of the worker are not necessarily lost, but can be gathered up into the germ-plasma of the species. In the second place, most, if not all of the characters of the worker are not qualitatively but only quantitatively different from those of the queen. In other words, the worker does not differ from the queen as a mutant, but as a fluctuating variation, which has been produced by imperfect or irregular feeding during its larval stages. This is true alike of morphological, physiological and psychological characters. Even when the queen fails to manifest the worker instincts, we are not justified in doubting her ability to do so under the proper conditions.

The hitherto unsuspected capacity of the queen ant is beautifully illustrated by another set of facts, which at the same time show the close connection between adaptive behavior and regulation, or regeneration. Under normal conditions the queen, after rearing a brood of workers, no longer takes part in the 'muck and muddle of child-raising' but seems to be as indifferent to the young of her species as some women who have brought up large families. If, however, the firstling brood of workers be removed and the queen isolated, she forthwith begins to bring up another brood, precisely as in the first instance, provided her body still contains sufficient food-tissue. She thus regenerates the lost part of her colony, just as a mutilated earthworm regenerates its lost segments. In the ant the absence of workers acts as a stimulus to restore the colony, just as the absence of segments leads the earthworm to complete its body.

The regulatory activities of the queen ant are, of course, highly adaptive and hence evidence of the variability which is so clearly manifested in the physical structure of these insects. There is no contradiction in the coexistence of such variability with the very stable character of certain instincts like those to which I have called attention, for an organism may be extremely plastic in some of its activities and rigidly conservative in others. It is evident that the remarkable variability of the female sex in ants—including under this term both the fertile, or queen phase, and the usually sterile, or worker phase—reaches its clearest expression in the extraôrdinary range of intraspecific polymorphism. In certain species, for example in the African driver ants (*Dorylii*) and American ants of visitation (*Ecitonii*), the structural differences between the workers of the smallest caste and the huge queen of the same species are enormous and represent an amplitude of variability in the female sex unequalled in any other organisms. Male ants, on the contrary, exhibit so little variability that it is often difficult, or even impossible, to distinguish the genera of single specimens of this sex. These facts have an important bearing on the views of authors like Brooks and Geddes and Thomson who assume that male animals are more variable than females, and of those authors who have transplanted this hypothesis to the fields of sociology and anthropology. All of these writers maintain a discreet and significant silence on the subject of the social insects. Equally astonishing, however, is the attitude of the biometricians, who, priding themselves on the accuracy of their methods and repudiating mere observation and speculation, proceed to an elaborate measurement of the wings of honey-bees and ants for the purpose of ascertaining whether males are more variable than females, when a glance at the personnel of a few ant and termite colonies would convince the most skeptical that there can be no such correlation between sex and variability as that assumed by the above-mentioned authors. If it is clear that the males of many of the higher animals are in certain characters more variable than the cospecific females, it is even clearer that the very opposite is true of the social hymenoptera, while in the termites, or white ants, both sexes seem to be alike variable and polymorphic.

THE DEVELOPMENT OF THE GLACIAL HYPOTHESIS IN AMERICA[1]

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GEOLOGY is preeminently a science of observation and deduction. Certain phases of it are, nevertheless, dependent upon advances in other branches. As the science grows this mutual interdependence becomes more and more apparent, and it is perhaps now questionable if further advance, aside from a purely geographic extension of knowledge relative to the distribution of geologic groups, is possible without calling in the aid of physics and chemistry.

Among those phases of geology which have been most independent of the allied sciences, and in which the gradual development of the power to observe correctly and deduce accordingly can incidentally be readily studied, the phenomena of the drift stand prominent. They furnish, moreover, an excellent example of the growth of knowledge through cumulative evidence, since of all phenomena, those relating to the drift have, in America, been perhaps longest under observation. In that which follows, however, it has been my principal aim to trace the gradual progress of the glacial hypothesis in America. Beyond this my references are purely incidental.

Out of numerous observations relating to the phenomena of the drift and, incidentally, to glaciation, those which seem most worthy of consideration at the present time were by Benjamin De Witt and are to be found recorded in the second volume of the 'Transactions' of the Philadelphia Academy for 1793.

De Witt noted the occurrence, along the shores of Lake Superior, of boulders representing a large variety of rocks, sixty-four different types being collected. In the discussion of this occurrence, he remarks:

> Now, it is almost impossible to believe that so great a variety of stones should be naturally formed in one place. . . . They must, therefore, have been conveyed there by some extraordinary means. I am inclined to believe that this may have been effected by some mighty convulsion of nature, such as an earthquake or eruption, and perhaps this vast lake may be considered as one of those great 'fountains of the deep' which were broken up when the earth was deluged with water, thereby producing that confusion and disorder in the composition of its surface which evidently seems to exist.

This, so far as I am aware, is the first attempt to account for the

[1] Adapted from a presidential address delivered December 13, 1905, before the Geological Society of Washington.

wide dispersion of drift boulders over the northern part of the country, although the glacial character of the same was not dreamed of.

The paper, so far as existing literature shows, caused little discussion, and we have next to refer to observations by Dr. Samuel Akerly, who, in 1810, published in Bruce's *American Mineralogical Journal* a geological account of Dutchess County, New York. After referring to the Highlands and the country to the northward, he described the southern part—that upon which the then existing city was built—as composed of an alluvion of sand, stone and rocks. This he looked upon as a recent deposit, 'subsequent to the creation and even the deluge.' The manner in which this material was deposited he described in the following language:

> After the waters of the deluge had retired from this continent, they left a vast chain of lakes, some of which are still confined within their rocky barriers. Others have since broken their bounds and united with the ocean. The Highlands of New York was the southern boundary of a huge collection of water, which was confined on the west by the Shawangunk and Catskill mountains. The hills on the east of the Hudson confined it there. When the hills were cleft and the mountains torn asunder, the water found vent and overflowed the country to the south. The earth, sand, stones and rocks brought down by this torrent were deposited in various places, as on this island, Long Island, Staten Island and the Jerseys. This opinion, he added, is mostly hypothetical, because unsupported by a sufficient number of facts.

A candid acknowledgment upon which the author is to be congratulated!

Whose was the master mind that first conceived of this great barrier which held back the flood of waters, so long made responsible for the drift, I have not been able to ascertain. The theory is, however, given in greatest detail by Dr. Samuel L. Mitchill in his 'Observations on the Geology of North America,' published in 1818.

It was Mitchill's idea that the Great Lakes are the shrunken representatives of great internal seas of salt water, which ultimately broke through their barriers, the remains of which he thought to be still evident. One of them he wrote, seemed to have circumscribed the waters of the original Lake Ontario and to be still traceable as a mountainous ridge beyond the St. Lawrence in upper Canada, passing thence into New York, where it formed the divide between the present lake and the St. Lawrence and continued to the north end of Lake George, apparently crossing the Hudson above Hadley Falls. Thence, he believed it to run toward the eastern sources of the Susquehanna, which it crossed to the north of Harrisburg, and continued in a southeasterly direction until it entered Maryland, passing the Potomac at Harpers Ferry into Virginia, where it became confounded with the Allegheny Mountains.

To appreciate Mitchill's views, then, we have to imagine this now broken and gapped ridge as continuous. A time came, however, when at various points it gave way, the pent-up waters rushing through and carrying devastation before them like the waters from cloud-burst or bursting reservoirs of to-day, but on a thousandfold larger scale. By this bursting all the country on both the Canadian and Fredonian sides must have been drained and left bare, exposing to view the water-worn pebbles, and the whole exhibition of organic remains there formed. Great masses of primitive rocks from the demolished dam, and vast quantities of sand, mud and gravel were carried down the stream to form the curious admixture of primitive with alluvial materials in the regions below.

A fresh contribution to the subject was rendered this same year, in the publication of Amos Eaton's 'Index to the Geology of the Northern States.' Eaton's views were in part, at least, a reflection of those of Werner. We have to do here, however, only with that portion of the work relating to the so-called alluvial class of rocks. In discussing this and attempting to account for the great masses of granite and syenite which he found scattered throughout the Connecticut River region, he wrote:

> What force can have brought these masses from the western hills, across a deep valley seven hundred feet lower than their present situation? Are we not compelled to say that this valley was once filled up so as to make a gradual descent from the Chesterfield range of granite, syenite, etc., to the top of Mount Tom? Then it would be easy to conceive of their being rolled down to the top of the greenstone where we now find them.

It was not easy in all cases for the geologists of these early days to distinguish between the younger and earlier drift, or between the material which we now consider as glacial drift and the loosely consolidated alluvial deposits of the Tertiary period. This seems particularly true of Dr. H. H. Hayden, a Baltimore dentist and one-time architect, who in 1820 published a volume of geological essays in which he dwelt very fully upon the lowlands, or the area at present comprised within the so-called Coastal Plain. After referring to the geographical limits of this plain and combating the opinions of previous observers, he elaborated his own theories somewhat as follows:

> Viewing the subject in all its bearings, there is no circumstance that affords so strong evidence of the cause of the formation of this plane as that of its having been deposited by a general current which, at some unknown period, flowed impetuously across the whole continent of North America in a northeast and southwest direction, its course being dependent upon that of the general current of the Atlantic Ocean, the waters of which were assumed to have risen to such a height that it overran its limits and spread desolation on its ancient shores.

In seeking the cause of this general current Hayden referred first to the seventh chapter of Genesis:

> For yet seven days and I will cause it to rain upon the earth forty days and forty nights, and every living substance that I have made will I destroy from off the face of the earth.

He then proceeded to show the inadequacy of rainfall alone, since the water being thus equally distributed over the ocean and the land, there could be no tendency toward a current. Some other cause must be sought, and, fortunately, his imagination proved equal to the task.

Accepting as probable the suggestion of one whom he designates as 'a writer of no common celebrity,' to the effect that the cause of the general deluge was a melting of the ice at the two poles of the earth, he proceeded to explain in his own way the details of the catastrophe, though acknowledging that no positive testimony could possibly be adduced to substantiate the fact.

Having admitted the possibility of the earth's changing its position, so that the sun would pass immediately over the two poles on an unknown meridian, he showed that there would then result a rapid dissolution of the existing ice-caps such as would yield an ample supply of material, it being only necessary to give it direction. Considering as essential to the problem only the northern hemisphere, he remarks that, from this polar cap there were but two outlets, the one into the Pacific through the narrow Bering Straits, and the other through the wider channel between Greenland and Lapland into the Atlantic. Hence, when the melting ensued, by far the larger volume of water passed into the latter ocean. No sooner was this operation established and this accession of strength and power thrown into the Atlantic Ocean in particular, than its tide began to rise above its common limits, accompanied by a consequent current, both constantly increasing, the one in height and the other in rapidity.

At the commencement of this frightful drama the current, it is highly probable, was divided by the craggy heights of Spitzbergen and a part thrown into the White Sea, while the other was thrown back upon the eastern and southern coast of Greenland and thence in a southwestern direction until it struck the southern coast of Labrador, along which it swept, through the straits of Belle Isle, across Newfoundland, Nova Scotia, and along the Atlantic coast into the Gulf of Mexico. In a short space of time the southern and eastern coast of Labrador was desolated. The soil was hurled adrift and carried across the country into the Gulf of St. Lawrence and across a part of New England into the sea or general current of the ocean.

Continuing to rise, the waters spread across Davis Straits and rolled their tumultuous surges into Hudsons Bay, embracing the whole coast of Labrador, while the current of the St. Lawrence was forced back and upward to its parent source.

At length the floods of the pole, forming a junction with Baffins Bay and the Arctic Sea, defying all bounds, overran their ancient limits and hurled their united forces in dread confusion across the bleak regions of the north to consummate the awful scene. Thus, lakes and seas uniting, formed one common ocean which was propelled with inconceivable rapidity across the continent between the chains of mountains, into the Gulf of Mexico, and probably over the unpeopled wilds of South America into the southern ocean. Fulfilled in this way were the awful denunciations of an offended God, by the sure extermination of every beast of the field and every creeping thing that crawled upon the face of the earth.

To these causes he believed to be due, not merely the deposits of the coastal plain, but, as well, the barrenness of Labrador and the northeastern portion of the continent, and the general phenomena of the glacial drift, the boulders of the latter being conceived as transported by floating ice.

These essays, it may be noted, were favorably reviewed by Silliman in the third volume of his Journal, even the idea of the fusion of the polar ice-cap being allowed to pass with no more serious criticism than that the flood of waters might have been produced through the expulsion of the same from cavities in the earth. J. E. DeKay, however, writing some years later, ventured to take exception to the views regarding drift boulders, wisely suggesting that, since the speculative part of geology is but a series of hypotheses, we should in every case admit that which explains the phenomena in the simplest possible manner. To his mind the simplest manner of accounting for these boulders was to suppose that such had been, as igneous material, extruded through the superincumbent strata, forming peaks which have since been destroyed through some convulsion of nature or through the resistless tooth of time, the boulders thus being fragments which had escaped destruction, though their place of extrusion had become completely obscured.

The observations thus far recorded display a lack of close attention to details and, in some cases, indicate a decided leaning towards cosmogony. Those to which I now call attention were of quite different type and show their author to have been a man of more than ordinary discernment.

While superintending excavations preliminary to the erection of a cotton mill at Vernon, Conn., Mr. Peter Dobson observed the boulders in what we now call the ground moraine or till, and in a letter dated November 21, 1825, described them as worn smooth on their under side as if done by having been dragged over rocks and gravelly earth in one steady position. They also showed scratches and furrows on the abraded parts. These appearances he could account for only by assuming that the blocks had been worn by being carried in ice over rocks and earth under water.

These observations seem to have attracted no attention at the time, and even Dr. Edward Hitchcock thirteen years later attached no serious importance to them, although his attention was called to the matter by another letter from Dobson, this time addressed to himself. In this last letter, written in 1838, Dobson described the boulders as having first been rounded by attrition and then worn flat on one side by a motion that kept them in one relative position, as a plane slides over a board in the act of planing. Some of them were described as worn and scratched so plainly that there was no difficulty in pointing out which side was foremost in the act of wearing, a projecting bit of quartz or feldspar protecting the softer material behind it. In this letter he again announced his inability to account for the appearances except on the supposition that they had been enveloped in ice and moved forward over the sea bottom by currents of water. The drifting icebergs of the Labrador coast he thought might well illustrate the conditions of their production.

Perhaps it may have been because Dobson was a cotton manufacturer and not a member of one of the learned professions, or there may have been other reasons, but Hitchcock allowed the observations to pass unnoticed until 1842, when the subject was brought up by Sir Roderick Murchison in his anniversary address before the Geological Society of London.

> I take leave of the glacial theory in congratulating American science in having possessed the original author of the best glacial theory, though his name has escaped notice, and in recommending to you the terse argument of Peter Dobson, a previous acquaintance with which might have saved volumes of disputation on both sides of the Atlantic.

Supported by this somewhat enthusisastic endorsement, Hitchcock then gave the letter to the public through the *American Journal of Science,* at the same time remarking that he had himself derived his ideas concerning the joint action of ice and water from the writings of Sir James Hall.

With this much in the way of anticipation, I will turn back to 1825 once more and refer to the writings of William Keating, mineralogist, who accompanied Major Long's expedition to the sources of the St. Peters River. This observer noted that the entire region of the present headwaters of the Winnipeek River had been at a comparatively recent period an immense lake, interspersed with innumerable barren rock islands, which had been drained by the bursting of the barriers which tided back the waters. This was plainly a recognition of the now extinct glacial Lake Agassiz.

Although the cosmogonist was fast drifting into the obscurity of the past, there were, nevertheless, occasional writers who preferred tc ignore facts of observation or the efficiency of simple causes, and to seek for more difficult or more mystical methods of accounting for phenomena than those afforded by the observation of processes now in action. Thus, Benjamin Tappan, in discussing in 1828 the boulders of primitive and transition rocks found in Ohio, objected to the commonly accepted idea that such were necessarily foreign to the locality and brought by currents of water or floating ice. He frankly acknowledged, however, his own inability to account for their presence, but ingenuously claimed that

> Ignorance is preferable to error. It may, therefore, be asked why may not these rocks have been created where they are now found, or, again, why may they not have been thrown up by earthquakes or volcanoes?

Groping though this writer may have been, it is questionable if his ignorance was not preferable to the kind of knowledge manifested by a writer in the *American Journal of Science* two years previously, who had accounted for the drift on the supposition that the earth's revolution, amounting to 1,500 feet a second, was suddenly checked. This, he thought, would result in the whole mass of the surface water rushing forward with inconceivable velocity until overcome by opposing obstacles or exhausted by continual friction and the counterbalancing power of gravitation. The Pacific Ocean would thus rush over the Andes and the Alleghenies into the Atlantic, which would, in the meantime, be sweeping over Europe, Asia and Africa.

> A few hours would cover the entire surface of the earth, excepting, perhaps, the vicinity of the poles, with one rushing torrent in which the fragments of disintegrated rocks, earth, and sand would be carried along with the wreck of animal and vegetable life in one all but liquid mass.

The first geological survey of an entire state carried through at public expense was that of Massachusetts, authorized by legislative enactment in 1830. Dr. Edward Hitchcock, then professor of chemistry and natural history in Amherst College, was selected to carry out the work. The report presented early in 1832 was, therefore, a document of unusual importance and, to a certain extent, epoch-making. Much that is of interest is to be found within its pages, but we must limit ourselves to that relating purely to the distribution of the numerous erratics for which the state is noted.

It is but natural that this drift should have been attributed to the Noachian deluge, when one considers that Hitchcock's training was that of a clergyman. Speaking of that about Cape Ann, he wrote:

> It can not fail to impress every reasoning mind with the conviction that a deluge of tremendous power must have swept over this cape. Nothing but a substratum of syenite could have stood before its devastating energy.

This observation is of importance, since here, for the first time, Hitchcock put himself on record in a line of investigation in which he became more widely known than in any other, with the possible exception of that relating to the fossil footprints of the Connecticut Valley.

In 1836 there was established a state geological survey of Maine, with C. T. Jackson, of Boston, at its head. Jackson's views on the glacial deposits, as expressed in the annual reports, were perhaps not more crude than those of the average geologist of his day. The 'horsebacks' (ridges of glacial gravel) were regarded by him as of diluvial material, transported by a mighty current of water which, he supposed, rushed over the land during the last grand deluge, accounts of which had been handed down by tradition and preserved in the archives of all people. "Although," he says, "it is commonly supposed that the deluge was intended solely for the punishment of the corrupt antediluvians, it is not improbable that the descendants of Noah reap many advantages from its influence, since the various soils underwent modifications and admixtures which render them better adapted for the wants of man. May not the hand of benevolence be seen working even amid the waters of the deluge?" he asks. It is, perhaps, doubtful if the hard-fisted occupants of many of Maine's rocky farms would be disposed to take so cheerful a view of the matter.

Substantially the same views were advanced by Jackson in his report on the geology of Rhode Island, which appeared in 1839.

> There can not remain a doubt but that a violent current of water has rushed over the surface of the state since the elevation and consolidation of all the rocks and subsequent to the deposition of the Tertiary clay, and that this current came from the north. . . . Upon the surface of solid ledges, wherever they have been recently uncovered of their soil, scratches are seen running north and south, and the hard rocks are more or less polished by the currents of water which at the diluvial epoch coursed over their surfaces, carrying along the pebbles and sand which effected this abrasion, leaving striæ, all of which run north and south, deviating a few degrees occasionally with the changes of direction given to the current by the obstacles in its way.

He did not accept the theory of drifting icebergs; 'nor,' he wrote, 'can we allow that any glaciers could have produced them by their loads of sliding rocks, for in that case they should have radiated from the mountains instead of following a uniform course along hillsides and through valleys.'

Although primarily a paleontologist, Timothy Conrad was sometimes drawn out of his chosen field by phenomena too obvious to be overlooked and concerning the nature of which little was actually known by the best authorities. The occurrence of enormous boulders in the drift, resting often upon unconsolidated sand and gravel, fell within this category. That such could not have been brought into their present position through floods was to him obvious, neither could they have been floated by ice floes from the north during a period of terrestrial depression. He assumed, rather, that the country previous to what is now known as the glacial epoch was covered with enormous lakes, and that a change in climate ensued, causing them to become frozen and converted into immense glaciers. At the same time elevations and depressions of the earth's surface were in progress, giving various degrees of inclination to the frozen surfaces of the lakes, down which boulders, sand and gravel would be impelled to great distances from the points of their origin. The impelling force, he thought, in some cases might be gravity alone, but during the close of the epoch, when the temperature had risen, vast landslides—avalanches of mud filled with detritus—would be propelled for many miles over these frozen lakes, and when the ice disappeared, the same would be deposited in the form of a promiscuous aggregate of sand, gravels, pebbles and boulders.

In 1840 an immense stride in the study of drift deposits was made through the publication of Louis Agassiz's 'Etude sur les Glaciers,' a work comprising the results of his own study and observation combined with those of Jan de Charpentier, E. T. Venetz and F. G. Hugi. The work was published in both French and German, and brought to a focus, as it were, the scattered rays by which the obscure path of the glacial geologist had been heretofore illuminated. It was Agassiz's idea, as is well known, that at a period geologically very recent, the entire hemisphere north of the thirty-fifth and thirty-sixth parallels had been covered by a sheet of ice possessing all the characteristics of existing glaciers in the Swiss Alps. Through this agency he would account for the loose beds of sand and gravel, the boulder clays, erratics, and all the numerous phenomena within the region described, which had been heretofore variously ascribed to the Noachian deluge, the bursting of dams, the sudden melting of a polar ice-cap, or even to cometary collisions with the earth. These ideas were favorably received by the majority of workers, though there was, naturally, a highly commendable feeling of caution against their too hasty acceptation. As a reviewer in the *American Journal of Science* expressed it:

> These very original and ingenious speculations of Professor Agassiz must be held for the present to be under trial. They have been deduced from the limited number of facts observed by himself and others and skillfully generalized, but they can not be considered as fully established until they have been brought to the test of observation in different parts of the world and under a great variety of circumstances.

The effect of this publication, however, soon made itself apparent in the current literature. Thus, in 1843 Professor Charles Dewey, writing on the striæ and furrows on the polished rocks of western New York, argued that, while the boulders of the drift indicated that a mighty current had swept from north to south, the polishing and grooving might be due to glaciers. 'Glaciers or icebergs and the strong currents of water—a union of two powerful causes—probably offer the least objectionable solution of those wonderful changes,' he wrote. Though thus disposed to accept in part Agassiz's conclusions, Dewey yet failed to realize their full possibilities.

He could not conceive how it was possible for a glacier to transport sandstone boulders from the shore of Lake Ontario to the higher level of the hills to the southward. Boulders of graywacke removed from the hills in the adjoining part of the state of New York and scattered throughout the Housatonic Valley furnished a like difficulty, since between the place of origin and that of deposit lay the Taconic range of mountains. "If," he wrote, "the boulders were once lodged on the glacier, the ice and boulders must have been transported by a flood of waters over the Taconic Mountains."

In 1842 Dr. Edward Hitchcock, already referred to in connection with Dobson's work, read an important paper before the Boston meeting of the American Association of Geologists on the phenomena we are now discussing, which is particularly interesting as showing the gradual evolution of the present theory from that of the Noachian deluge idea, advocated by the earlier workers. His views had evidently been modified by the publication of Agassiz's work and by the writings of Buckland, Murchison, Dobson and others, and he expressed at the outset the conviction that nearly all geologists would agree in the principle that the phenomena of drift were the result of joint and alternate action of ice and water. To express this joint and alternate action he made use of the term aqueo-glacial.

In this paper Hitchcock devoted some fifty pages to a description and discussion of observed phenomena, after which he proceeded to discuss the theories of the various European authorities and state his agreement or objections to the same. He objected to the theory of Lyell, to the effect that the results observed by him in North America were produced by floating icebergs derived from glaciers formed on mountains as the land gradually emerged from the ocean, because, first, it failed to account for the lower temperature which was necessary; second, because there was no evidence that the glaciers descended from the mountains; and third, because the deposits of vegetable matter derived from land plants showed that the continent must have been above sea-level long before the drift period.

The theory of De la Beche, which supposed the contents of the northern ocean to have been precipitated over the countries further south by the elevation of the polar regions, Hitchcock regarded as possibly applicable to the low countries of Europe, but not to New England, since it would require a rise of the ocean amounting to some 6,000 feet, and he could find no facts to justify such an assumption, although recognizing the fact that the aqueo-glacial agency had operated well over the summits of the White Mountains.

To Agassiz's theory, which supposed an immense accumulation of ice and snow around the poles during the glacial period and a consequent sending out of enormous glaciers in a southern direction, followed by enormous floods of water and transportation of icebergs on return of a warmer period, he likewise took exception, since he was unable to conceive how such effects could be brought about. Nor, indeed, could he understand how such causes could operate when the land was rising from the ocean and the water consequently retreating, as it must have been to account for the various observed phenomena—such phenomena as would necessitate the occurrence of water loaded with ice and detritus floating for centuries at least over a large part of the earth's surface.

His paper showed a very clear insight into what had taken place, but an inability, with the information at that time available, to account for it in a satisfactory manner. Thus, in describing the striæ found by himself on the top of hills and mountains like Monadnoc, he wrote:

> Could immense icebergs have been stranded on the northern slope of the hills and afterwards, by the force of currents, have been driven over the summits; or would it be necessary to suppose that, after the stranding, the water must have risen so as to lift the iceberg; or would a vast sheet of ice lying upon the earth's surface, by mere expansion, without the presence of water, have been able to produce the smoothing and furrowing in question?

After considering the phenomena and weighing all the theories advanced from time to time by the authorities quoted, he summed up the matter in the following words:

> Is it not possible that the phenomena of the drift may have resulted from all the causes advanced in the theories under consideration? I feel . . . that the proximate cause of the phenomena of drift has at last been determined, namely, the joint action of water and ice.

In 1836 there was organized a state geological survey of New York, which was placed in charge of W. W. Mather, Ebenezer Emmons, Lardner Vanuxem and James Hall—men whose names have since become too thoroughly identified with American geology to ever become eradicated. Naturally drift phenomena attracted the attention of these workers, and each expressed opinions, some of which may be referred to in detail.

Seventy-five pages of Mather's report, as published in 1843, were given up to descriptions and discussions of drift phenomena. He concluded that the transport of the material and the production of scratched surfaces were contemporaneous, the drift itself being transported in part by currents and in part by ice itself drifted by the currents. The period of the drift and that of the quaternary deposits were separated by a partial submergence of the land, and, further, the periods of the drift were periods when the currents were stronger than at the present time. He conceived this to be due to a collapse of the crust of the globe upon its nucleus, causing an acceleration of the velocity of rotation, and this causing, in its turn, a disturbance of the form of equilibrium of the spheroid of rotation which had been compensated by the flow from the polar regions and an accelerated flow to the equatorial regions. This sudden acceleration of the ocean currents he felt would be sufficient to cause the transportation of vast quantities of detritus-laden ice from the polar regions southward. The large amount of drift scattered over the central and northern Mississippi region he ascribed incidentally to ice-laden currents from

Hudsons Bay and the polar seas, which, floating over the northern part of the United States, would be met by the warm waters of the Gulf Stream, causing them to deposit their loads. The warm current flowing northward would be superimposed on the cold current, the latter continuing southward beneath it, transporting the finer materials, such as now occupy the lower Mississippi Valley.

Emmons likewise believed the agent of drift transportation to be water and ice. The boulders he thought to be the work of icebergs, but the striations and polishing he felt could not be due to this agency, since the bottom of the ocean is not bare rock, but covered by debris, and, moreover, icebergs would not move in straight lines, a point which some more recent writers have quite overlooked. The bergs might act as agents of transportation, he argued, but not of erosion. According to his ideas the drift-covered region was, during the drift period, depressed, the country low and connected at the north with an extensive region giving rise to large rivers which flowed in succession over different parts of the region lying between Champlain and the St. Lawrence. These rivers united with the Atlantic on the south through the Champlain, Hudson and Mohawk valleys. They bore along ice loaded with sand, pebbles, etc., which scratched and grooved the surface of rocks over which they flowed, and were the agents also of perforating the rocks in the form of pot holes.

Hall's ideas were somewhat hazy. That he did not accept Agassiz's doctrine of a vast ice sheet is very evident. Thus, he wrote that

> Blocks of granite, either enclosed in ice or moved by other means, have been the principal agents effecting the diluvial phenomena; that they have scored and grooved the rocks in their passage and, breaking up the strata and mingling themselves with the mass, have been drifted onward carrying everything before them in one general mêlée. That such may have been the case in some instances or in limited localities, can not be denied; but that it ever has been over any great extent of country will scarcely admit of proof.

Hall was at this time evidently a catastrophist and regarded the drift soils, terraces, and the deep valleys and water courses as due to the violent action of water which may have been caused in part by a sudden submergence and the rapid passage of a wave over its surface. His views, indeed, were in many respects little, if any, in advance of those held by Mitchill twenty-five years earlier. Like Mitchill, he conceived of an inland sea bounded and held back by the Canadian highlands on the north, the New England range on the east, and highlands of New York and the Alleghenies on the south, and the Rocky Mountains on the west. These presented barriers of from one thousand to twelve hundred feet above the level of the ocean until broken through by the St. Lawrence, the Susquehanna, the Hudson, partially by the Mohawk at Little Falls, and perhaps also by the Connecticut.

> But to whatever cause we attribute the phenomena of the superficial detritus of the fourth district, the whole surface has been permanently covered by water, for it seems impossible that partial inundations could have produced the uniform character and disposition of the materials which we find spread over the surface.

Under the caption 'Description of a Singular Case of Dispersion of Blocks of Stone Connected with the Drift, in Berkshire County, Mass.,' Dr. Edward Hitchcock came forward in the *American Journal of Science* for 1845 with a description of that remarkable train of boulders extending from Fry's Hill in the Canaan Mountains of New York, southeasterly into Massachusetts for a distance of some fifteen or twenty miles, which have since become more generally known as the Richmond Boulder Train. The lithological nature of the boulders was such that they could be traced to a common source and were described as forming three somewhat meandering trains, extending from Fry's Hill, through the adjoining valley, and upwards over an elevation of eight hundred feet at the state line, across the Richmond valley, over Lenox Mountain, six hundred feet in height, to and over Beartown Mountain, one thousand feet in height. Naturally, so striking a phenomenon excited investigation, and, naturally, too, Dr. Hitchcock, in the then existing condition of knowledge, found difficulty in accounting for the same. He recognized the similarity of the trains to the lateral moraines described by Agassiz, but he could not conceive of a glacier traveling directly across the intervening ridges, even were there mountains in the vicinity of sufficient altitude to give rise to the same. Neither did the consideration of river drift or floating ice afford him a satisfactory conclusion:

> In short, I find so many difficulties on any supposition which I may make that I prefer to leave the case unexplained until more analogous facts have been observed.

Unsatisfactory and apparently unimportant as this paper may at first thought seem, it is questionable if the contribution were not worthy of greater commendation than the one put forward three years later by the Rogers brothers, to which I now refer.

According to the descriptions given, the trains start, each from its particular depression in the summit of a high ridge in Canaan, N. Y. Taking a direction south 35° east, they cross the higher ridges and their intervening valleys, the longer for a distance of twenty miles and the shorter for ten miles. The individual trains are none of them more than three hundred or four hundred feet in breadth and not over half a mile asunder. The transported blocks of all sizes up to twenty feet in diameter, sharply angular, free from scratches, and all of the same lithological nature, identical with that of the ridge whence they start. That such a dispersion of boulders from a single point should have taken place regardless of contours is certainly enough to excite the interest of any one. It is the means invoked by the two workers which have excited our wonder, however.

After exhibiting to their own satisfaction the inadequacy of either the iceberg or the glacial hypothesis to account for their production, the authors attempted to show how all the phenomena might be explained by the theory of a sudden discharge of a portion of the Arctic Ocean southward across the land. They discussed the important functions of the 'wave of translation,' showing its surpassing velocity and great propulsive power, and traced the influence of vehement earthquakes near the pole in dislodging the northern waters and ice and maintaining in the rushing flood these vast and potent waves. They then suggested that, at a certain stage of the inundation, the ice, previously floating free, might impinge with irresistible violence against the tops of submerged hills, and that the Canaan Mountain stood precisely in the position to take the brunt of the ice-driving flood as it swept down the long, high slope of the distant Adirondacks and across the low, broad valley of the Hudson.

They then proceeded to show that, at the instant when some enormous ice island struck the crest of the mountain and scooped the trench which we there behold, a great vortex was produced by the obstruction thus suddenly thrown in the path of the current, which, endowed with an excessive gyratory or spiral velocity, was capable of sustaining and carrying forward the greater part of the fragments. As in the instance of the waterspout and the whirlwind, the whirlpool would gather into the rotating column the projected blocks and strew them in a narrow path in the line along which its pendent apex would drag the ground.

Truly there were catastrophists in those days!

Agassiz, it will be remembered, came to America in 1846, and in 1847 was appointed to the professorship of geology and zoology in Harvard. Naturally, an attempt was made to apply his views on glaciation to the phenomena of the drift in America. In the summer of 1848, in company with Jules Marcou and a party of students, he undertook the exploration of the Lake Superior region, the results of which were published in 1850. The views set forth relating to the glacial phenomena of the region are of paramount interest.

He argued that the drift of all northeast America and northwest Europe was contemporaneous and due to a general ice sheet. Through a repetition of many of his former arguments, he showed that a current of water sufficiently powerful to transport the large blocks found would have swept practically over the entire globe and not have stopped abruptly, as did the drift, after reaching latitude 39° north. This limit of distribution of the boulders to the northern latitudes also indicated to his mind that the matter of climate was an important factor. Water-transported material, he argued, would not cause straight furrows and scratches, and the theory that such might be due to drifting icebergs was rejected on the ground that existing bergs were insufficient, and to produce such as were would necessitate a period of cold sufficient for his hypothetical polar ice-cap. He pointed out that the northern erratics were rounded and widespread; that the highest hills were scratched and polished to their summits, while to the south the mountain tops had protruded above the ice-sheet and supplied the glaciers with their load of angular boulders. He also called attention to the absence of marine or fresh-water shells from the ground moraine deposits, showing that it was not subaqueous.

Referring to the stratified deposits overlying the drift, he wrote:

> The various heights at which these stratified deposits occur above the level of the sea show plainly that since their accumulation the mainland has been lifted above the ocean at different rates in different parts of the country; further, it must be at once obvious that the various kinds of loose material all over the northern hemisphere have been accumulated, not only under different conditions, but during long-continued subsequent periods. To the first, or ice, period belong all phenomena connected with the transportation of erratic boulders, polishing, scratching, etc., during which the land stood at a higher level. To the second period belongs the stratified drift such as indicates a depression of the continent.

In 1856 Dr. Edward Hitchcock came once more to the front, through the medium of the 'Smithsonian Contributions to Knowledge,' with a paper of some 150 royal quarto pages and 12 plates, in which he considered the changes which had taken place in the earth's surface since the close of the Tertiary period. The products of these changes he classed as, first, drift unmodified, and second, drift modified, including under the latter such deposits as ancient and modern beaches, submarine ridges, sea bottoms, osars, dunes, terraces, deltas and moraines. The drift proper he regarded, as before, as a product of several agencies, including icebergs, glaciers, land slips and waves of translation, which, though more active in the past than now, are still in operation.

To account for the drift accumulations at various altitudes he conceived that the water must have stood some 2,500 feet above its present level and, further, that all the northern part of the continent—at least all east of the Mississippi—had been covered by the ocean since the drift period.

As to the origin of the material of the irregular coarse deposit beneath the modified beaches and terraces (ground moraine), he agreed essentially with Naumann in supposing that, first, the eroding materials must have been comminuted stone; second, they must have been borne along under heavy pressure; third, the moving force must have operated slowly and with prodigious energy; and fourth, moving in a nearly uniform direction, though liable to local divergence; fifth, the vehicle of the eroded material could not have been water alone; but, sixth, a firm and heavy mass, somewhat plastic. The exact period of operation of the drift agency he naturally found difficulty in determining, and felt that, while the greater part of the work was accomplished before the continent had emerged very considerably from the waters, nevertheless, the work of erosion went on for some time after emergence began.

It was in this connection that was made the first suggestion, so far as I am aware, of a possible recurrence of glacial periods, as fully elaborated later by Chamberlin. Referring to the occurrence of two series of striæ, the direction of which did not coincide, and the possible existence of still a third series, he wrote: 'Perhaps there were two periods of glaciers, one before, and one subsequent to the drift.'

The facts concerning the dispersion of boulders Hitchcock thought could be more satisfactorily explained by icebergs than glaciers, since the transportation and scattering continued until after the time when a large part of the beaches and terraces were formed. Glaciers, he thought, would have plowed tracks through stratified deposits. Icebergs such as now traverse the Atlantic might carry boulders over the beaches and terraces and drop them from time to time, forming thus the intermixture of coarse angular blocks and beach and terrace material, as we now find it.

> The supposition that a glacier once existed on this continent wide enough to reach from Newfoundland to the Rocky Mountains is the grand difficulty in the way of the glacial theory.

The writings of the Rogers brothers are singularly lacking in more than casual references to the drift, though, in one case, at least (that relating to the Richmond boulder train) they advanced some theories which were extraordinary, to say the least. In the, for its time, magnificent publication of the first geological survey report of Pennsylvania one would naturally look for an extension of the views of Professor H. D. Rogers, but such, nevertheless, are not found. The fact that he considered, if not fully comprehended, Agassiz's views is shown only by a brief paragraph in which he described and figured drift striæ seen on an exposed surface of umbral sandstone on the south side of the Wyoming Valley. These he described as 'pointing up the slope toward the southwest, as if produced by fragmentary debris violently propelled against the slope of the mountain wall of the valley from the south.' The presence of such ascending striæ, both here and elsewhere, effectually refuted, according to his conception of it, the glacial theory of their origin.

Like Hitchcock, he failed to conceive of other than local mountain glaciers of the Swiss type, and he gave the following, even then antiquated, matter for a general discussion of the distribution of the drift and the various phenomena accompanying it. Of the earlier drift, it should be noted, he offered no explanation whatever, other than that implied in a reference to a period of repose 'which separated the convulsed epochs of the earlier general and later local drift.'

A ready explanation of the origin of this newest Pleistocene deposit (*i. e.*, that of the Hudson and Lake Champlain districts) suggests itself when we consider the nature and energy of the crustal movements which lifted the Laurentian clays and sands to a height, in one locality at least, of not less than five hundred feet, and which drained wide tracts of the upper Laurentian Lakes.

The mere agitation or pulsating movement of the crust, if accompanied by any permanent uplift of the land, would suffice, we would think, by lashing the waters of the tidal estuaries in one quarter and the lakes in the other, to strew a portion of the older drift bordering all those basins in wide dispersion upon the top of the more tranquil sediments. But if such a pulsation of the crust were accompanied by successively paroxysmal liftings of wide tracts of the land, then the inundation would take the form of stupendous currents, the strewing power of which would be adequate to any amount of superficial transportation, even to the remote transportation of the larger erratics.

In 1861 the Natural History Survey of Maine was inaugurated and C. H. Hitchcock was placed in charge of that portion relating to geology. Of his work, only that relating to glaciers concerns us here. He noted that the fossiliferous marine clays which were regarded as of the same age as similar deposits along the St. Lawrence and Champlain valleys and referable to the terrace period, sometimes underlay a coarse deposit referable to the modified drift. Without committing himself definitely on this point, he suggested the possibility, therefore, of a recurrence of the drift agencies, that is, a period of second drift, as had the elder Hitchcock fifteen years earlier.

The drift period itself, according to Hitchcock's view as here expressed, was inaugurated by a depression of this portion of the continent amounting to at least 5,000 feet below that of to-day, and it was during this period of depression and reelevation that the drift deposits were formed through the joint agency of icebergs and glaciers.

In 1862 J. S. Newberry expressed his views on glaciers in an article on the 'Surface Geology of the Basins of the Great Lakes.' After reviewing the surface conditions as he saw them, he came to the conclusion that, at a period corresponding in climate, if not in time, with the glacial epoch of the old world, the lake region, in common with all the northern portion of the American continent, was raised several thousand feet above the level of the sea. This was to him the glacial period, during which the surface of the country was planed down and the deep fiords along the Atlantic coast formed. This was followed by a period of depression, when all the basin of the Great Lakes was flooded with fresh water, forming a vast inland sea in which the laminated blue clays (the oldest drift deposits) were precipitated.

Subsequent to this deposit of blue clay an immense quantity of gravel and boulders was transported from the region north of the Great Lakes and scattered over a wide area south of them. This he regarded as due to floating ice and icebergs.

It would seem that, if one were looking for original observations on drift phenomena, he might turn with safety to the writings of the

Canadian geologists. Singularly enough, the views are, if anything, less original than those of the workers on this side of the line. The establishment of a geological survey of Canada under Logan led to the publication of the now well-known volume of 1863. The views here expressed may be accepted as a summary of the knowledge relating to the glaciation on Canadian territory, as it then existed.

Concerning the region of the lake basins of western Canada, Logan wrote:

> These great lake basins are depressions, not of geological structure, but of denudation, and the grooves of the surface rocks which descend under their waters appear to point to glacial action as one of the great causes which have produced these depressions. This hypothesis points to a glacial period when the whole region was elevated far above its present level and when the Laurentides, the Adirondacks, and the Green Mountains were lofty Alpine ranges covered with perpetual snow from which great frozen rivers or glaciers extended over the plains below, producing by their movements the glacial drift and scooping out the river valleys and the basins of the great lakes.

In his address before the Natural History Society of Montreal in 1864 J. W. Dawson took occasion to combat vigorously these ideas of Logan, and this on the ground that 'it requires a series of suppositions unlikely in themselves and not warranted by facts'; that it seems physically impossible for a sheet of ice to move over an even surface striating it in uniform directions over vast areas; that glaciers could not have transported the large boulders and left them in the positions found, having no source of supply; that the peat deposits, fossils, etc., show that the sea at that period had much the same temperature as the present arctic currents, and that the land was not covered by ice.

In describing the course of the rock striæ he announced that he had no hesitation in asserting that the force which produced those having a westerly direction was from the ocean into the interior against the slope of the St. Lawrence Valley, and as he could not conceive of a glacier moving from the Atlantic up into the interior, he considered this as at once disposing of the glacial theory. He conceived, rather, that a subsidence took place sufficient to convert all the plains of Canada, New York, and New England into seas. This, he felt, would determine the direction of the Arctic current which moved up the slope. He would account for the excavations of the basins of the Great Lakes by supposing the land so far submerged that an Arctic current from the northeast would pour over the Laurentian rocks on the northern side of Lake Superior and Lake Huron, cutting out the softer strata and at the same time transporting the debris in the form of drift to the southwest. Glaciers were not wholly dispensed with, but limited to regions of mountainous elevation.

J. S. Newberry, while director of the geological survey of Ohio (1869–78) had frequent occasion to discuss glacial phenomena, and a review of his opinions may be given in some detail. Beginning with the later Tertiary times, he believed the following sequence of events to have been established.

(*a*) During Miocene and Pliocene epochs a continent several hundred feet lower than now, the ocean reaching to Louisville and Iowa, with a subtropical climate prevailing over the lake region, the climate of Greenland and Alaska being as mild as that of southern Ohio at present.

(*b*) A preglacial epoch of gradual continental elevation, which culminated in the glacial epoch, when the climate of Ohio was similar to that of Greenland at present, and glaciers covered a large part of the surface down to the parallel of forty degrees.

(*c*) This period followed by another interval of continental subsidence characterized by a warmer climate and melting glaciers and by inland fresh-water seas filling the lake basins, in which were deposited the Erie and Champlain clays, sands and boulders.

(*d*) Another epoch of elevation which is still in progress.

The sheet of clay and boulders which was found directly overlying the polished surface of the rocks over so large a part of the state, now known under the name of till and boulder clay, he described under the general name of glacial drift, while the loose boulders which he found scattered indiscriminately over the surface, frequently resting on the fine stratified clays, were known under the name of iceberg drift.

If, he wrote, we restore in imagination this inland sea, which we have proved once filled the basin of the lakes, gradually displacing the retreating glaciers, we are inevitably led to a time in the history of this region when the southern shore of this sea was formed by the highlands of Ohio, etc., the northern shore a wall of ice resting on the hills of crystalline and trappean rocks about Lake Superior and Lake Huron.

> From this ice wall masses must from time to time have been detached, just as they are now detached from the Humboldt glacier, and floated off southward with the current, bearing in their grasp sand, gravel and boulders—whatever composed the beach from which they sailed. Five hundred miles south they grounded upon the southern shore—the highlands of now western New York, Pennsylvania and Ohio, or the shallows of the prairie region of Indiana, Illinois and Iowa. There melting away and depositing their entire loads.

The loess, as one would naturally expect from the foregoing, was looked upon as the finer sediment deposited in the quiet waters of one of these inland seas, to which the icebergs had no access. The lake basins, with the exception of that of Lake Superior, were regarded as excavated by glacial action—thus agreeing with Logan.

The views of Orton, who succeeded Newberry as state geologist, were not widely different, and, briefly expressed, were as follows:

Threefold divisions of glacial time may be considered as demonstrated: (1) An age of general elevation of northern land, accompanied by intense cold and the formation of extensive continental glaciers; (2) a general depression of the land, with the return of a milder climate; (3) a partial reelevation of the land and a partial return of the cold climate, producing local glaciers and icebergs.

E. T. Cox, while state geologist of Indiana, encountered phenomena in every way similar to those described by Newberry and Orton, and it is to be expected that his mode of accounting for the same would be somewhat similar. In his report of the conduct of the survey of that state (1869–79) he announced his acceptation of the general theory of glacial drift, as at that time understood, and conceived that the necessary climatic changes might be due to the relative position of land and water, and, possibly, a change in the course of the Gulf Stream. He could find, however, no evidence of a subsidence of the land to terminate the glacial period, nor could he find in Ohio, Indiana or Illinois anything to militate against the commencement of the glacial period in Tertiary times and its continuation until brought to a close by its own erosive force aided by atmospheric and meteorological conditions. By these combined agencies acting through time the mountain home of the glacier was cut down and a general leveling of the land took place. This suggestion that the glacial epoch worked out its own destruction through a process of leveling, whereby the altitudes which gave it birth were so far reduced that glaciers could no longer exist, is unique and, so far as the present writer is aware, original with Cox.

The organization in 1876 of a state geological survey of Wisconsin afforded Professor Chamberlin and his assistants opportunity for investigation of the drift phenomena of that state, and in the pages of his reports his views are distinctly formulated. He divided the glacial period into: (1) The terrace or fluviatile epoch, (2) Champlain or lacustrine epoch, (3) the second glacial epoch, (4) the interglacial epoch and (5) the first glacial epoch. This formal announcement of the possibility of two distinct periods of glaciation was here made for the first time, although, as before noted, Edward Hitchcock had at an earlier date suggested such a possibility.

Not content with a mere discussion of the glacial phenomena, Chamberlin considered also matters relating to the cause of glacial movement. The law of flowage he announced as being, in his opinion, similar to that of viscous fluids—this in accordance with the observations of Agassiz, Forbes, Tyndall and others. A later study of Greenland glaciers, as is well known, has caused him to change his views on this point.

In the third edition of his work on 'Acadian Geology,' which appeared in 1878, J. W. Dawson returned once more to a vigorous discussion of the problems of the ice age, and to register again his opposition to the views generally held by American geologists. Many of the arguments used closely resembled those of his former papers and may be reviewed here for the last time.

He regarded the phenomena of the boulder clay and drift in eastern America as due to the action of local glaciers, drift ice and the agency of cold northern currents. Against the theory of a universal glacier he again argued on the ground that such suppositions were not warranted by the facts.

> The temperate regions of North America could not be covered with a permanent mantle of ice under existing conditions of solar radiation; for, even if the whole were elevated into a tableland, its breadth would secure a sufficient summer heat to melt away the ice except from high mountain peaks.

For the supposition that such immense mountain chains existed and have disappeared, he found no warrant in geology, and for such an 'unexampled astronomical cause of refrigeration' as the earth's passing into a colder portion of space, he found no evidence in astronomy. He agreed with Lyell in regarding the theory of the varying eccentricity of the earth as expounded by Croll as insufficient; moreover, it seemed to him physically impossible that a sheet of ice, such as that supposed, could move over an uneven surface, striating it in directions uniform over vast areas and often different from the present inclination of the surface.

He was further influenced in his opinion by the work of Hopkins, who showed, apparently, that only the sliding motion of glaciers could polish or erode rock surfaces, and the internal changes in their mass—the result of weight—could have little or no effect. Glaciers, moreover, he argued could not have transported the boulders great distances and lodged them upon the hill tops, and the universal glacier would, moreover, have no gathering ground for its materials. The huge feldspar boulders from the Laurentide Hills, stranded at Montreal Mountain at a height of six hundred feet above the sea and from fifty to sixty miles further southwest, and which must have come from little, if any, greater elevation and from a direction nearly at right angles to that of the glacial striæ, were against the ice-sheet theory, as were also the large boulders scattered through the marine stratified clays and sands, and the occurrence of marine fossils in the lower part of the drift in the true till near Portland, Maine, and at various points on the St. Lawrence in Canada.

To substantially these views Dawson held to the very last. In his 'Ice Age in Canada' (1893) he is found still combating vigorously the idea that all northern Europe and America were covered by a *mer de glace* moving to the southward and outward to the sea, and which moved not only stones and clay to immense distances, but glaciated and striated the whole surface. The glacial theory of Agassiz and others he described as having grown, until, like the imaginary glaciers themselves, it overspread the whole earth. He adopted, rather, what he called the moderate view of Sir Roderick Murchison and Sir Charles Lyell to the effect that Pleistocene subsidence and refrigeration produced a state of our continents in which the lower levels, and at certain periods even the tops of the higher hills, were submerged under water filled every season with heavy field ice formed on the surface of the sea, as at present in Smith's Sound, and also with abundant icebergs derived from glaciers descending from unsubmerged mountain districts. The later Pliocene, so far as Canada was concerned, he considered to be a period of continental elevation and probably of temperate climate.

Thus far the discussion relating to the ice period has been limited wholly to workers and areas east of the Mississippi River. In 1880 and 1882 J. D. Whitney, one time state geologist of California, issued his well-known work on climatic changes of later geological time, in which he discussed the occurrence of glaciers and their possible origin in the west, particularly in the region of the Great Basin. Whitney thought to be able to trace a period of warmth and heavy precipitation, followed by one of desiccation, but anticipated by one of cold and glaciation, the glaciers, however, being limited to the most elevated ranges of the Cordilleras. At the outset he announced himself as opposed to the 'wild and absurd ideas' that had prevailed regarding glaciation in the Sierras, and stated it as his belief that here, at least, ice had played but an extremely subordinate part as a glacial agent, though 'there is no doubt but that the great California range was once covered with grand glaciers, but little if at all inferior to those which now lend such a charm to the Swiss Alps.'

It was Whitney's opinion, further, that the geological importance of the ice sheet had been greatly exaggerated. It seemed to him beyond question that icebergs had played an important part in carrying and distributing the large angular boulders which in many places rest upon the surface in such a manner as to show that they could not have been placed in their present position by running water or by a general ice sheet.

He regarded it as evident enough that the climate of northeastern America during the glacial epoch was a period of greater precipitation than now, but that it was a period of intense cold he would not admit. Glaciation or a glacial period was due merely to increased precipitation. In order that such precipitation should take place, an increased evaporation from the land and water was necessary. This could be brought about only by a general increase of temperature. The amount of precipitation being sufficient, the production of glaciers would depend upon temperature, which itself would be dependent upon local conditions, which again might, or might not, be due to elevation of land surfaces. His idea, in brief, was that while during the glacial epoch there might be over the entire globe a period of sufficient warmth to produce the desired evaporation, the precipitation would fall as rain or snow, according to the local uplift or depression. That the glaciers are now retreating in nearly every instance, he regarded as due, not so much to a change in climate, at least not to a gradual increase of temperature, but rather to a gradual decrease in the amount of annual precipitation.

In this connection, it may be mentioned that Whitney considered the movement of glacial ice due to water:

> Glacier ice is not simply ice, but a mixture of ice and water, and it is to the presence of the latter that the whole mass owes its flexibility. The larger the amount of water, other things being equal, the more easily the glacial mass moves. When the water increases so as to get the upper hand, the ice gives way with a rush and becomes an avalanche. . . . The extreme variation of the rate of motion of different glaciers coming down from the inland ice of Greenland is due to the different amounts of water which they have imbibed.

More recent observations than those quoted are familiar, and we may well stop here. That, at a period geologically not very remote, a vast sheet of ice and snow, with all the attributes of a modern glacier, or series of glaciers, covered the northeastern United States and eastern Canada, that this sheet advanced, retreated, and again advanced, and finally utterly disappeared, is the commonly, though not universally, accepted view. The causes which led up to this condition are still problematical. Whether due to cold from increased elevation, as taught by Dana, to astronomical causes, as taught by Croll, or merely to an increase in precipitation, as argued by Whitney, or to a combination of any or all of these causes, is the great problem awaiting solution, if solution is possible on other than a theoretical basis. Chamberlin, the Dawsons, Gilbert, Hall, the Hitchcocks, Lewis, Mather, Newberry, Salisbury, Upham, Winchell, Wright and a score of others have made us acquainted with the physical characteristics of drift deposits and their geographic distribution, but the first-named alone, among Americans, has put forward a satisfactory working hypothesis as to the cause of glacial motion.

Leaving out of consideration Peter Dobson, whose views were not pushed to their legitimate conclusions, the world at large must credit Louis Agassiz, born in Switzerland, but an American by adoption, with being the great promoter and, perhaps, originator of the glacial hypothesis as it exists to-day. His method of procedure, it is interesting to note, consisted in applying what one of our prominent geologists has slightingly referred to as the principle of prolonging the harmless and undestructive rate of geological change of to-day backwards into the deep past.

THE EARLIEST PREDECESSORS OF COPERNICUS

By Dr. CHARLES R. EASTMAN,
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THE first glimmerings of perception that presage the discovery of great truths, whether coeval with, or long antecedent to complete apprehension, possess for most minds a fascinating interest. Whether it be abstract ideas, epoch-making inventions or discoveries of fundamental laws, such as gravitation or evolution, matters not; the names of those who have contributed largely toward intellectual progress, even if they fell short of the whole truth—if they merely prepared the way for final discovery—become universally reverenced, or acquire at least a romantic interest, by virtue of their heraldry. In natural science, as elsewhere, it is right and fitting that a high place be reserved for the advance prophets who have preceded the great expounders of Nature's truths.

By common consent of mankind, the Copernican cosmogony ranks as one of the immortal triumphs of genius, whence it follows that not only the monk of Frauenburg, and the scarcely less famous defenders of his theory, but also his remote predecessors, are entitled to an exalted position amongst those favored mortals who have been permitted, in one age or another, to wrest from Nature the solution of her deepest mysteries. Yet because of the absolute originality of the great sixteenth-century astronomer's discovery; because, furthermore, the anticipators of his theory failed to convert the world to their belief; and because Copernicus himself knew nothing of his real predecessors, it has come about that too little credit is commonly bestowed upon ancient forerunners of our modern system.

There is abundant and undisputed testimony to show that in the minds of at least two astronomers prior to the Christian era, namely, Aristarchus of Samos, and Seleuchus the Chaldæan, the essential features of our modern system were clearly recognized, and elaborated not only into a working hypothesis, but into a valid explanation of the universe. It is impossible to view this achievement in its manifold relations to human progress, without being impressed with the pathetic and remarkable fact that a ray of divine intelligence should have shone forth for an instant in that far-off period, kindling here and there a momentary spark; sparks that, although revealing the true order of the cosmos, were not finally to illumine the world until after the lapse of centuries.

No demonstration is necessary to show that the beginning of astronomical knowledge is a subject in which all intelligent persons are interested. Indeed, precisely this sort of interest is recognized by Professor Simon Newcomb as one of the characteristics of modern science. The opening words of his presidential address at the St. Louis Congress tell us that "among the tendencies characteristic of the science of our day is one toward laying greater stress on questions of the beginnings of things, and regarding a knowledge of the laws of development of any object of study as necessary to its complete understanding in the form in which we find it."[1] But interest alone is scarcely sufficient to overcome the difficulties which beset the general reader in quest of information, owing to the exceedingly scattered, and more or less special nature of the literature. The absence, too, of a popular conspectus which treats in satisfactory manner of the origin of the heliocentric hypothesis, is to be regretted.[2] Hence the present article has been prepared with the idea of affording those who may be inquisitive as to the sources of information with the means of orienting themselves.

In order to keep the relations of the founders of different cosmical systems firmly in mind, the distinguishing features of the latter may be pointed out, with indication of the most prominent names associated with each. Four distinct systems may be recognized, according as the center of the universe is supposed be occupied by (1) a central fire, other than our sun (Philolaus the Pythagorean); (2) by a stationary earth about which the heavens revolve (Eudoxus of Cnidos, Ptolemy, Tycho Brahé); (3) by an earth rotating upon its axis, but otherwise immovable (Heraclides of Pontus); and (4) by the sun, about which the entire planetary system revolves (Aristarchus, Copernicus). As thus outlined, the transition between the third and fourth of these systems appears at first sight abrupt, but examination of the views of Heraclides shows that he too recognized the competency of the modern system as a working hypothesis, and thus helped prepare the way for its rigorous adoption. It is evident, also, that a somewhat remote

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[1] 'The Evolution of the Scientific Investigator' (opening address of the president of the International Congress of Arts and Science, at the St. Louis Exposition), *Science*, Vol. XX., p. 385.

[2] The treatises by Berry ('A Short History of Astronomy,' London, 1898), and Miss Agnes Clerke (in Appleton's 'Concise Knowledge Library,' New York, 1898), contain but a bare mention of the prior establishment of the Tychonian and Copernican systems amongst the Greeks. Even the elaborate work of Sir George Cornewall Lewis ('An Historical Survey of the Astronomy of the Ancients,' London, 1862) can hardly be said to do justice to the evolution of these systems. The French reading public is more fortunate than ours, having a goodly number of popular works at its disposal. Two only need be mentioned here, each of them being provided with ample bibliographical references. These are: Thirion, J., 'L'evolution de l'astronomie chez les Grecs' (Brussels, 1900); and Bonnel, J. F., 'Étude sur l'histoire de l'astronomie: la Découverte du double Mouvement de la Terre' (Tours, 1886).

connection can be traced between the last of these systems and the first, a correspondence which did not escape notice by Copernicus himself.[3]

Familiar as Copernicus undoubtedly was with Pythagorean doctrines, how are we to explain his silence regarding the system of Aristarchus? The answer lies in the fact that he never had access to the writings of Archimedes, which furnish our chief information in this matter; indeed he could not, for the reason that the *editio princeps* was not given to the world until the year following his death in 1543.

For a succinct statement of the views of Aristarchus, as reported in the *Arenarius* of the famous Syracusan, one may refer to an article by Professor Holden in an earlier number of POPULAR SCIENCE MONTHLY (April, 1904). The original text of the passages, both in the *Arenarius* and in Copernicus relating to them, together with a variety of precious documents extracted from ancient authors, is appended to the anniversary memoir of Professor Schiaparelli, prepared in honor of the fourth centenary of the birth of Copernicus.[4]

At the same time it must be admitted as at least curious that the brief sentence in Plutarch (*de Placitis Philosophorum*, II., 24), in which Aristarchus is represented as having reckoned the sun amongst the category of fixed stars, and to have conceived of the earth revolving around it, should have passed altogether unnoticed by Copernicus. Almost the identical words are repeated by Stobæus in his *Eclogæ Physicæ*, and in the distorted abridgment of Plutarch's treatise which passes under the name of *Historia Philosophica*, often erroneously attributed to Galen; but we must suppose that none of these statements attracted the attention of Copernicus, even if he was aware of their existence. The same remark applies to passages concerning Aristarchus which occur elsewhere in Plutarch and amongst other authors, fortunately in considerable number. Those desirous of consulting them

[3] The system of Philolaus is twice mentioned by Copernicus in his famous work, 'De Revolutionibus Orbium Cælestium,' first in the dedicatory epistle to Pope Paul III., and again in the fifth chapter of Book I. Upon these passages, which gave rise to heated discussions a few decades after the death of Copernicus, Professor Schiaparelli comments as follows:

'Neppure qui è possibile inferire, che nella mente di Copernico il sistema di Filolao fosse il sistema eliocentrico. Anzi, le caute e indeterminate espressioni . . . mostrano che le parole di Plutarco più sopra citate non gli sembravano abbastanza decisive per invocare l'autorità di Filolao in favore del sistema da lui [*i. e.*, Copernicus] propugnato."— *I Precursori di Copernico*, etc., p. 9, note 20.

[4] Published in the *Memoirs of the Royal Lombardy Institute*, Vol. XII., and also in the Publications of the Milan Observatory, No. 3, 1873. A German translation by Curtze exists under the title of 'Die Vorläufer des Copernicus im Alterthum' (Leipzig, 1876). Three other invaluable historical memoirs by the same author have appeared in the Lombardy Memoirs, the latest one (1898) dealing in consummate manner with the 'Origin of the Heliocentric Planetary System amongst the Greeks.' These contributions are absolutely indispensable for students.

in the original, and of comparing the opinions of learned critics, will readily be directed to them by the special literature.[5]

Contenting ourselves with these brief literary indications, we may pass on to the more intricate questions relating to the predecessors of Aristarchus, and the influence of Pythagorean views upon later thinkers. As has been previously remarked, Heraclides Ponticus acknowledged that the heliocentric theory provided an adequate explanation of celestial phenomena, and even approached so nearly to modern ideas as to maintain the revolution of Mercury and Venus about the sun. This we know from the testimony of numerous authors, chiefly Roman, amongst whom Heraclides was held in high regard. Of interest is the passage in Simplicius ('Commentary on Aristotle's *de Cœlo,*' Karsten's edition, p. 232), which shows Heraclides' correct apprehension of the causes determining the difference in length between the sidereal and ordinary day of twenty-four hours. We are informed, however, by Plutarch (*Plac. Philos.*, III., 13) and later writers (*e. g.*, Simplicius, Hippolytus, Proclus, Chalcidius, and especially Vitruvius and Terentius Varro) that although Heraclides of Pontus and Ecphantus the Pythagorean believed the earth to turn upon its axis from west to east, they distinctly denied to it a movement of translation through space. It is clear also from Aristotle that it was no unheard-of thing to explain the apparent diurnal motion of the heavens upon the hypothesis of the earth's rotation. Plato appears to have accepted this idea as the starting-point of his system, complicated as it was with superadded mechanism. But the great Athenian appears to have elaborated his cosmical theory more as a speculative abstraction than as an orderly induction from observed facts, and it was easy to explain the discrepancy of the latter as due to false appearances.

It has been claimed on the authority of Theophrastus, as reported by Plutarch and Aristotle, that Plato repented in his old age at having placed the earth at the center or 'altar' of the universe, this being deemed too sacred a position for it to occupy (Plutarch, *Plat. Quæst.*, VIII. 1; Aristotle, *de Cœlo,* II. 13, 3). But this is very far from indicating that the heliocentric theory ever fully shaped itself in his mind, although one sees that it required merely a combination of his views and those of the Pythagorean school to arrive at a cosmical

[5] Besides the writings of Schiaparelli above mentioned, one should not fail to consult H. Martin's works, especially his 'Etudes sur le Timée de Platon,' Vol. II. (Paris, 1841), and Paul Tannery's 'Recherches sur l'Histoire de l'Astronomie ancienne' (Paris, 1893). The fourth essay in Bergk's 'Abhandlungen zur Geschichte der griechischen Philosophie und Astronomie' (Leipzig, 1883) is devoted to Aristarchus. The older work of Schaubach contains some rather adverse estimates, no longer considered tenable. On Pythagorean doctrines, one of the most critical essays in English is by George Grote: 'Plato's Doctrine respecting the Rotation of the Earth, and Aristotle's Comment upon that Doctrine' (London, 1860).

system identical with that which we call Copernican. Moreover, if we may trust to a somewhat obscure statement in Simplicius, there lived in the time of Alexander the Great an individual whose name we know not, but who actually did effect a combination of these ideas, and who is therefore worthily entitled to rank as a predecessor of Copernicus. Whether the heliocentric conception was ever presented to Aristarchus in concrete form, or was independently excogitated by him, we are without information; but it is impossible that his mind should not have received some fertile stimulus from the ideas already extant concerning the earth's revolution and rotation. Indeed, the way had been fairly prepared for a realization of the Copernican system; and as a matter of fact it was easier to arrive at this conception in the time of Aristarchus than subsequently, when the scheme of planetary movements had become hopelessly obscured through the invention, by Apollonius of Perga, of eccentrics and epicycles. The transition from Philolaus to Aristarchus is natural and easy as compared with the truly Herculean feat performed by Copernicus, who had first to clear away heaps of Augean refuse before the truth could again become manifest.

A melancholy interest in the fate of Aristarchus bids one inquire the reasons which prevented his theory from obtaining foothold. So far as history tells, it found but a solitary champion in the person of Seleuchus,[6] who flourished half a century later than Aristarchus. To Archimedes, and presumably to contemporary mathematicians and philosophers, the insuperable objection to this system consisted in its stationing the fixed stars at an infinite distance from the earth. Moreover, as witness the clamant protests against the Sage of Athens—to say nothing of the witty caricatures of him in the 'Clouds'—followed in the end by his martyrdom; and as witness the charges preferred against Aristarchus by Cleanthes, any dislodgment of the earth from its sacred position in the 'hearth of the Universe' was tainted with suspicion of impiety. And when afterwards the Ptolemaic mechanism was introduced, blocking with its devices the brilliant conception of Aristarchus, fourteen centuries were required to roll by before this useless débris could be swept away.

Possibly yet other circumstances conspired to hinder the acceptance of the heliocentric system, the nature of which can not now be ascertained, any more than can the reasons which first carried conviction of its truth. But this much is clear, there can be a tragic history of ideas no less than of individuals; and in meditating on the fate of the many 'struck eagles' of the pagan world, who soared loftily even where we now stumble, one is reminded of that beautiful simile of Byron, which concludes in deepest pathos:

> Such is the aspect of this shore;
> 'Tis Greece, but living Greece no more!
> . . . .

[6] *Cf.* Ruge, S., 'Der Chaldäer Seleukos,' Dresden, 1865.

THE GREATEST NEED IN RESEARCH

By Professor M. V. O'SHEA,
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ANY student of social progress might learn a useful lesson if he would attend a convention of the National Educational Association, which, in the general character of its work, is typical of the numberless educational organizations existing among us. He would find the most complicated questions of educational procedure being discussed by a body of men of the most divergent interests, training and experience—by prominent public officials who may boast of the fact that they were not trained in the schools themselves; by college presidents and professors in technical departments who have never given an hour's thought to the principles of education; by normal school principals and school superintendents, who devote all their energies to executive details; and in addition to these one may listen to dogmatic opinions regarding studies and methods from editors of the secular and professional press, parents and citizens, merchant princes, bankers, lawyers, physicians, ministers—any one who has attracted attention in any field of practical activity is likely to be invited to give teachers directions as to how they should 'train up the rising generation.' The sort of person who will be least in evidence at the convention is he who is carefully investigating some particular problem of education according to scientific methods. Program makers usually do not wish 'theoretical' or 'laboratory' papers; they want something 'spicy,' 'concrete,' 'practical,' 'common sense.' Study the programs of educational gatherings, and note how largely they are devoted to the exploitation of mere opinion based upon incidental and shallow observation. One does not often hear a governor, say, or a college president, or a professor of Greek, or an editor of a daily paper, instructing physicians regarding the nature of disease and how it should be treated; but such persons will often dogmatically lay down the laws to teachers respecting educational values and methods. They justify themselves on the ground of superior 'common sense'; specialists, they say, men who devise ways to overcome the universal tendency to interpret everything in the light of individual experience and preconceptions, so that they may examine the phenomena in a special field with an eye single to the truth—such men are not generally favored by the gods with well-balanced minds, and only the man who knows a little of everything, but nothing particular about the subject he discusses, is competent to give sane advice as to the rearing of the young.

In almost every field of human activity outside of education the expert alone, who has become possessed of special knowledge, can gain a hearing and a following. Improvement along most lines of human endeavor has been achieved only by clearing the way of the 'common-sense' men; they always block rational progress, for they never penetrate beneath the surface of any problem. When any particular department of social activity is largely dominated by such men it must certainly lag behind those departments where fact is esteemed more highly than mere fancy, and where searching for truth is more prominent than the promulgation of individual opinion. Little was understood of the laws of nature until people with scientific interests abandoned the 'common-sense' notions of the universe which were current among men until within recent times, and devoted themselves to tracking out these laws without preconception or bias. The mind of the 'common-sense' man, as we find him in daily life, functions only for the purpose of getting his own prejudices adopted by his fellows. He is not fitted, intellectually or temperamentally, to discover the deeper-lying truths in any field. He is a partisan, an advocate, not a truth-seeker; and he must be ejected from every scientific camp before advance can be made.

Consider what would be the situation to-day in physics, or chemistry, or electricity, or medicine, or mechanics, or law, if every aspiring person in the community could set himself up as an authority in any of these fields, and he should be given a chance to disseminate his views. In these departments a man who poses as an authority without having mastered at least the rudiments of the subject he treats is cast into outer darkness without ceremony or apology; but he may be welcomed by teachers if his rhetoric is pleasing, and he claims fellowship with the 'common-sense' tribe, or if he has a reputation for greatness in some sphere of action, though quite remote from education. Educational people have had a liking beyond other persons, perhaps, for generalities and commonplaces and oratory and hero-worship; science has not been emotional enough; it has required too precise thinking, and to appreciate it has involved too elaborate training.

But we are beginning to see evidences of brighter days ahead. The scientific temper is beginning to show itself in those who treat of education. There is developing in some quarters discontent with the methods that have been pursued in discussing questions of education, and we are just ready to enter upon an era of educational investigation in accord with strict scientific method. Men are coming to realize that traditional educational dogmas are, in considerable part surely, founded upon the shifting sands. In many other fields there would be no rest or peace until all this folk-lore had been subjected to scientific test; and it looks now as if the educational world was on the eve of a period of stress and struggle in the effort to examine the character of the foundations upon which all our theory and practise are built. The National Educational Association has established a fund for research; a society for the scientific study of education has been formed in our country; two or three of the universities have established chairs of educational research; a number of men have put themselves into training for the new work; and these are but preliminary signs of the impending revolution in the treatment of education.

And we shall need to start practically at the beginning in our research. Much, perhaps most, of contemporary educational opinion is in dispute, and we can not be certain where the truth lies. Take such a simple matter as the teaching of the three R's; while we are agreed that every child should gain some familiarity with these branches, yet we have the most diverse theories as to at what age we should introduce him to them, just what he should get from each, whether they should be acquired in isolation or correlated with other branches, how they may be most economically mastered, and so on *ad libitum.* For the asking, and even without it, we can get all sorts of opinions on these problems from all sorts of persons from college presidents up and down; but who among all these has resolved any one of these well-nigh infinitely complex questions into its elements, as scientific procedure demands, and observed it under varying conditions, so that its precise value could be determined? 'Common sense' does not realize that these problems are complex; it catches some shallow, immaterial aspect of any situation, and jumps to the easiest conclusion, missing most of the vital factors of the problem. Much of our traditional educational theory has been established in this way; it is in some such condition to-day, as natural science was when Bacon began applying exact methods to the study of natural phenomena. We have a great deal of hearsay knowledge about human development; but when one attempts to administer educational forces with precision, certainty and efficiency, he realizes how much guesswork there is in current pedagogical opinion. Science is only just beginning to touch questions of development at all; men in all fields of living nature have been concerned primarily with mature things, analyzing and dissecting and classifying. Even medicine has given us little of value regarding the healthful physical development of a human being. We have almost no precise knowledge respecting problems of food, clothing, sleep, exercise, the effects of school-life and the like upon an individual at different periods in his development. We have an unlimited body of conflicting lay opinion upon these matters, and a considerable body of conflicting expert (?) opinion as well; but if a layman who has children to bring up, say, should consult all these opinions in the hope of getting some aid in his task, he would be more likely to be confused than enlightened. Take the current standard literature on the feeding of children, for instance, and you will find exactly opposite opinions expressed upon the most vital matters by equally 'eminent authorities'; and you will discover that we have but little on this subject which has been worked out with due regard to scientific accuracy. The trouble is that a man who may be an authority in some phase of the malfunctioning of the adult organism, but who has made no exact studies upon the developing organism, does not hesitate to dogmatize about the latter in the light of his experience with the former. While doubtless he may be partially right in his views, still what we now need is precision as a result of special research in the field of human *development,* physical as well as intellectual and moral. Here is the great necessity and the great opportunity for research.

Doubtless one, and it may be the principal, reason why research in education has lagged far behind that in many other fields is because the practical work of instruction has absorbed the attention and energies of educators. There has been so much to do in carrying out the conventional educational régime that men have not had leisure to even investigate the foundations of this régime. Teachers are always confronted by situations where something *must be done immediately,* and they are compelled to act in view of what seems traditionally best. It is not permitted them to doubt the validity of the principles transmitted to them, for to doubt is to become static, and the great public demands action of a clearly obvious nature. Then naturally, of course, when the teacher acts on a principle through necessity, he becomes its exponent and defendant, and easily convinces himself that it is sound, and in this way he helps to pass it on as truth to his associates. Heretofore there has been no body of men in education, as there has been in other fields, who have been sheltered from the urgency of people of utilitarian impulses and needs, and who have been given leisure to work out problems without feeling that principles and rules of practical value must be elaborated at once right out of hand. In physics and chemistry and agriculture and medicine and other departments there are men at work who devote all their time and energies to original investigation, and they are not coerced into forming hasty opinions in order to gratify a public demand; but it is quite different in education. The supreme need to-day in this latter department is the development of a body of investigators who will be recognized as such, and who will be protected from the importunities of the practical people about them. Taken as a whole, the universities, some of which make reasonably liberal provision for research in the physical sciences, agriculture, medicine and the like, make no provision whatever for research in education.

The majority of them yield to the general clamor for something immediately serviceable in reference to teaching, and so they engage two or three instructors who are expected to give themselves entirely to the work of instruction, and to enlisting the support of the teachers in their several communities for their respective universities. The situation would not be so much in need of remedying if the normal schools were making any progress in research, but they too are engrossed with immediately practical affairs. They must look to other institutions—properly the universities—for new light, and they will then spread it among the people.

It is worthy of remark that a country which keenly appreciates the necessity of scientific experimentation in agriculture, and carries it on very effectively, should not think it needful to provide for similar experimentation in the care and culture of human beings during the formative period. Some one may ask whether the National Bureau of Education is not an investigating institution; and the answer is that is not intended to make, nor is it making, the slightest contribution to educational science, except in so far as the gathering of statistics regarding school attendance, the wages of teachers, the progress of new studies, as manual training and nature study and the like, may be found to bear in some way upon educational theory. It can not take the initiative in any research; it can simply report what is being done. The men who manage our educational finances have evidently imagined that since so many people are engaged in educational work they would be constantly pushing forward into the unknown, ever widening the boundaries of knowledge about human nature and the means of influencing it most effectively and economically. But it is just as reasonable to assume that practical farmers will continually develop the science of agriculture without experiment stations, or that practical doctors will develop the science of medicine without research laboratories, as to assume that practical superintendents and principals and class-room teachers will develop the science of education without special schools for investigation.

MAKING GEOGRAPHY WHILE YOU WAIT

By THOMAS H. MACBRIDE,
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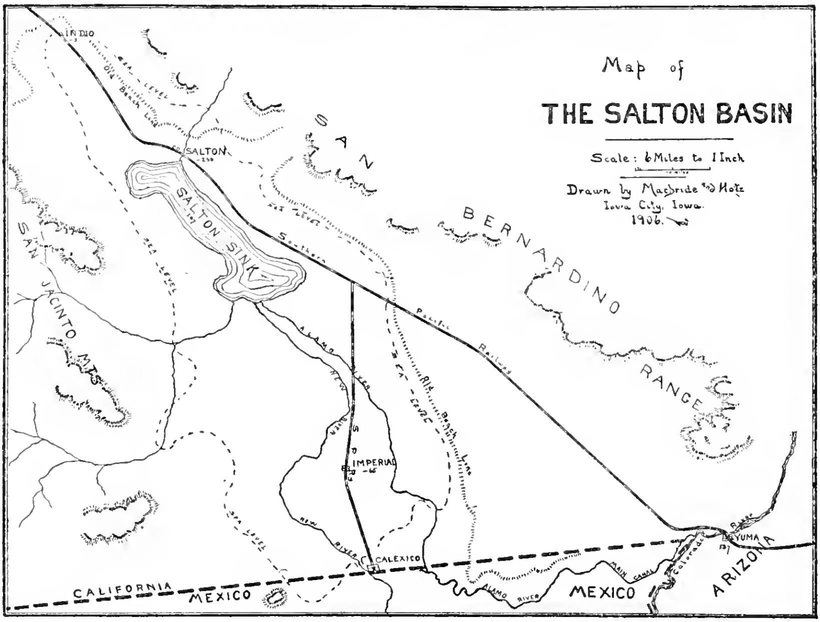
THOSE who read the daily newspaper, and the number of such is confessedly great, have no doubt been more than once of late mildly excited by certain sensational despatches from California, despatches intimating that certain large portions of that much-advertised commonwealth are actually rapidly disappearing from the sight and touch of men. It is reported that a large valley in the southernmost portion of the state is vanishing; has been assaulted by the sea; volcanoes are breaking up the solid ground beneath and the gray ocean is coming in to cover up the universal ruin.

Now something might be said in apology for the real-estate men of California who let go their holding in presence of assaults like these; and if it can be shown that any considerable bit of realty is actually disappearing and escaping, the violence of the natural agency responsible becomes a matter of probability, at least.

But it must be admitted that for the sensational stories referred to there is a certain basis of fact. In the Salton desert of southern California, where less than two years ago the traveler on the Southern Pacific railway saw only a wide vista of drifting sand, he now may skim along for miles beside a spreading sea, a sea that deepens from day to day and widens every moment. Within less than two years over many square miles, the whole face of the country has been changed. Railroads have been whelmed, stations and houses and factories lost in one encroaching flood; gulls and cranes run along a level beach where but a few months since the sage-hen nested, or the wild rabbits hid in sandy burrows. Surely, whether Neptune and Vulcan are busy or not, something has happened, and the passing traveler would like to know.

If we consult a map of the region in question and at the same time study the levels of the country, even as cited in the railway folder, though these are inexact, we shall speedily discover that the old Salton desert is indeed a basin, a basin of remarkable depth for its expanse, and wonderful in many ways. To make the case as simple as possible, the altitudes of points on the accompanying map are indicated. It appears, for instance, that the altitude of the station at Yuma, just east of the basin, is one hundred and thirty-seven feet. While the height of Salton station, about the middle of the valley, now whelmed, is actually two hundred and sixty-two feet below the level of the sea, say at the head of the Gulf of Lower California, about a hundred miles away! Indio, another railway station about one hundred and twenty-five miles west of Yuma and about twenty-five west of Salton, is almost at sea-level, so that it is evident that we have here a great depression not only below the Colorado which passes Yuma, but actually away below the



level of the sea. The extent of country actually below sea-level is included by the dotted lines upon our map. Now it is evident that if the volcanoes should once conclude to open up a way for oceanic waters, the sea might easily take possession of the Salton basin as the newspapers say; but have they done it?

It has been noted that the Colorado River at Yuma is far above the bottom of our basin, and it skirts along our southeast border to the gulf all the way, of course, far above the valley. In fact, with respect to the basin and its sloping sides, the river occupies exactly the position of a great irrigating main carried along some hillside above waiting fields. Some years ago enterprising men who saw the situation, realizing that large areas of the basin were not sand at all, but the finest sort of fertile alluvial soil, began to use this great natural main by constructing a secondary, carrying the waters of the Colorado out to the south part of our basin, near the Mexican boundary, where it was easy to bring under water some 100,000 acres of beautiful land. This artificial channel should bring part of the water of the river to certain old river channels emptying, or rather opening, into the lower part of the Salton basin. Recently, for the sake of wider service, new intakes from the Colorado have been opened. All went well until some eighteen months since, when the Colorado, flushed with flood, rose suddenly twenty feet or more above its usual tide and forthwith, instead of hurrying its waters southward to the gulf, began to pour them down the old abandoned river channels into the Salton sink. The fall to the gulf is only one hundred and thirty-seven feet, while the fall to the basin is, as we have seen, nearly four hundred and the distance not much greater! So there you are; and no earthquakes, volcanoes or sea-water needed in the least!

The whole situation and topography are interesting in the extreme. The geologist will tell you that all the region hereabouts is slowly rising; that once upon a time the head of the Gulf of California was farther north, away north of Yuma, in fact, and received the Colorado there, perhaps where the United States government is now building the new dam; and more, an arm of the gulf extended away west nearly to where now is Indio; and in those days the mud of the stream was deposited farther and farther out in the sea, forming an estuarine deposit, filling up the sea, while, upon the rising bottom, channels of the river ran carrying the mud farther and farther until finally the part of the sea toward Indio was cut off entirely from what now is called the Gulf. The part of the ocean thus isolated presently dried up and left the Salton basin, a salt desert by reason of the evaporated sea-water; and now again, though filled with the fresh water of the river, the wide-forming lake is salt once more in memory of its old-time history.

The botanist too finds curious confirmation of our story. All about the Salton valley, as near Indio and the Palm springs farther west are curious isolated groves of palms, palms of peculiar sort, the *Washingtonia,* in fact, now commonly planted in south California cities. But *Washingtonia* should stand by the sea, as the palms of Florida do, run down the shores of the California Gulf—and so these isolated groves are but the remnant of a tropic flora, once rich no doubt, that all but perished with the drying of the old Salton Sea of which geology tells. The old sea was a fact. Part of this beach is yet to be discovered, as is shown upon our map, and no doubt its course might be traced more widely still; its sands along the old-time eastern shore are still blowing about in dunes.

The waters of the Colorado, if allowed their present course, will no doubt bring back conditions of climate long gone by. Already railroad men declare the air too moist. If so, would the palms again extend their sway along the shores and would tropic verdure once more make the bordering mountains green? Who knows?

EXTRA DIGITS AND DIGITAL REDUCTIONS

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ALTHOUGH the mammalian extremities are nicely adapted by their structure to the functions they perform, the number of digits frequently varies from the normal. Moreover, different degrees of digital reduction may be observed in the extremities of animals whose habits are apparently identical. It is generally recognized that the digits of many mammals have been reduced to adapt the foot to rapid locomotion, but the evidence is chiefly circumstantial. In the present paper the writer will attempt to reconcile the various theories accounting for supernumerary digits, to call attention to certain evidences of reversion which may be daily observed, and to point out some little recognized factors concerned in the evolution of the mammalian foot.

We may assume that the primitive and typical mammalian foot was pentadactyl, in spite of Bardeleben's contention that the progenitors of the mammalia possessed not five but seven digits. Bardeleben's assumption was based upon the observation that certain mammals, the whale, for example, have more than five digits; that among five-toed forms six and seven digits occasionally occur; and that in many species small cartilages are present on each side of the hand and foot. These cartilages Bardeleben regards as digital rudiments, and the occurrence of extra digits is explained by him as reversion, a 'turning back' through heredity, to ancestral conditions. Unfortunately, the facts do not support this beautiful theory. Paleontology tells us that the forerunners of the mammalia possessed only five toes. Embryology has shown that the sixth digit of the whale, and the cartilages which Bardeleben supposes to be digital rudiments, develop secondarily some time after the typical five digits have appeared. Finally, observations have proved that the extra digits which occur in polydactylism do not develop from Bardeleben's 'digital rudiments,' but originate in an entirely different manner. We may, therefore, assume that the primitive mammalian foot was pentadactyl, and this being so, the occurrence of six or seven digits on a foot normally five-toed can not be attributed to reversion, unless we assume with Albrecht that it is reversion to the many-rayed fins of the Elasmobranch fishes, an absurd supposition. Such cases of polydactylism are, nevertheless, of frequent occurrence on the appendages of man and the cat. They have been explained as due to bifurcations or duplications of one of the typical five digits. Dissections show that this is really the case, for, though the skeletal elements are often distinct from each other, muscle tendons and nerves are bifid, and in many cases the bones of the extra digit are more or less closely united to those of a normal toe. The question next arises as to whether these digital bifurcations are due to external influences or to internal variations of the germ plasm. Ahlfeld has observed that digital duplications may be caused 'in utero' by pressure from the thread-like outgrowths of the amnion. He attempted to make this explanation cover all cases of polydactylism, but there are several serious objections. In the first place, the extra digits generally occur on both hands or on both feet, often on all four extremities (Fig. 1, *A–D*). The middle digits, moreover, are not generally affected, but the duplication is chiefly of the first and fifth. Finally, and most important, the abnormality is strongly inherited and may increase in degree during successive generations. Thus Fackenheim cites the case of a woman born of normal parents. She had the little finger duplicated on each hand. Of two sons, one inherited the mother's extra fingers and the other had besides extra small-toes on both feet. Of eight children, three were normal, three had six toes and two had six fingers on both right and left extremities. In three succeeding generations the abnormality appeared, now on the hands, now on the feet, and in two cases on all *four* extremities; in two cases *seven* toes were present on both feet.

Similar observations have been made by Poulton and Torrey in families of cats. It is evident that extra digits produced by the chance pressure of amniotic threads would not be inherited, and that such chance pressure would certainly affect now one digit, now another; whereas, we have seen that the first and fifth digits are chiefly affected. Of twelve cases studied by the writer all were of the latter type.

It will be observed in Fig. 1, *A–D*, which represent the extremities of one child, that the fifth digit is affected differently in each case. In fact, it has been pointed out that occasionally no extra digit may be produced, that the first or fifth digit may simply be abnormally large. These facts, together with the frequent inheritance of the extra digits, show that we have to do here with variations of the germplasm. The first digit of man has been modified, and the fifth slightly reduced. Variation most often affects organs whose structure has been recently changed, and the variation or duplication of these digits might be naturally expected.

We are warranted, then, in assuming that the abnormal occurrence of six or seven digits on the five-toed extremity is not due to reversion. They are rather duplications of the normal digits, produced either by external influences or, more frequently, by germinal variation.

As the five-toed extremity is the primitive type of mammalian foot it is but natural to conclude that the appendage with less than five toes has lost some of the original number of evolutionary changes. The circumstantial proofs of such reductions are too well known to require more than a brief statement. Rudiments supposed to represent the absent first digit are found in the pes of the dog and the manus of the pig (Figs. 2, *A*, 3, *C*). The feet of sheep and cattle exhibit pairs of vestigial bones and hoofs, called the rudiments of digits 2 and 5; the splint bones of the horse are believed to be the vestiges of the second and fourth digits. These rudiments are often better developed in the embryo than in the adult. Thus of the dog's hallux only the upper part of the metatarsal bone remains. According to Bonnet, all the skeletal parts of this digit are formed in the embryo. The second and fifth digits of the sheep, represented by mere vestiges of the phalanges, are fully developed in the lamb. The foot of the adult horse shows only the metacarpals and metatarsals of digits 2 and 4; but in the embryo the writer has observed two cartilaginous phalanges on the metacarpal bones. Paleontology completes the ring of circumstantial evi-

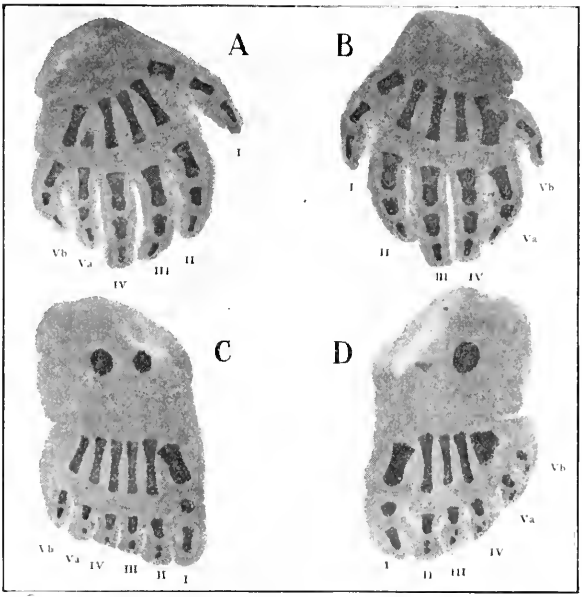


FIG. 1. X-ray photographs of a child's extremities showing duplication of the fifth digit in both hands and both feet. *Va*, *Vb*, the digits produced by duplication.

dence by showing us that the ancestors of the swine had five instead of four toes and that the forerunners of the ruminants and the Equidæ had three, four or five functional digits.

The question now arises as to whether the occurrence of *extra* digits on extremities normally possessing less than five toes is due to duplication, as in pentadactyl animals, or are the extra digits developed from the rudimentary structures we have described? If it can be shown that the supernumerary toes are due to reversion, we have no longer

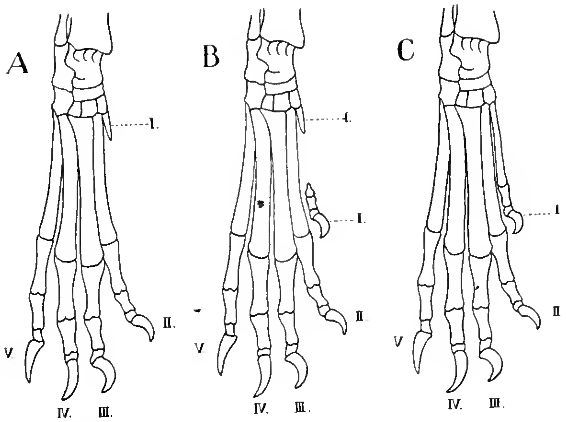


FIG. 2. A series showing the normal and polydactyl structure of the skeletal elements in the pes of the dog. *A*, normal pes with the rudimentary metatarsal bone of digit I.; *B*, a polydactyl pes, the hallux represented by two phalanges and the distal end of the metatarsal bone: *C*, polydactyl pes with hallux (I.) completely developed.

circumstantial evidence, but direct proof that the extremities of the ungulate have been derived by evolution from a five-toed type. This is an important point, but one about which investigators have been at variance. Bardeleben, Kollman, Marsh, Blanc and others recognize all cases of polydactylism as due to reversion. Gegenbaur warns us against such general conclusions, but admits that the extra digits sometimes found on the extremities of the horse are developed from the digital rudiments. Weismann, Bateson and Wilson ascribe all such abnormalities to germinal variation. But germinal variation may affect the rudimentary as well as the functional digits; if through such variation the supposed rudiment of a thumb develops into a digit with two phalanges, germinal variation and reversion are one and the same thing.

To attempt to reconcile the conflicting statements of various investigators the writer has made a comparative study of polydactylism in mammals normally possessing less than five toes. It was found that in the majority of cases the extra digits *are* developed from the so-called digital rudiments. This is most frequently observed in the pes of the

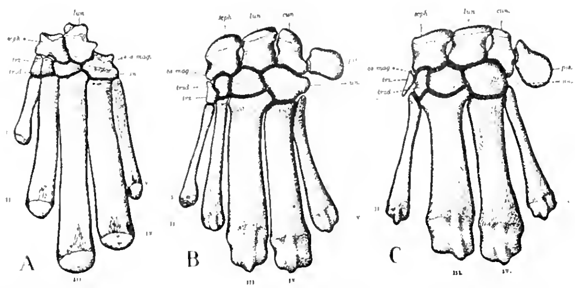


FIG. 3. A series to show the reversion of the pig's manus to the pentadactyl condition. *A*, carpals and metacarpals of the fossil Ancodus; *B*, of a polydactyl pig; *C*, of a normal pig. *I.-V.*, first to fifth digits; *trz.*, trapezium, the carpal element of the pollex.

dog. Normally the hallux, or great toe, is represented only by the proximal end of the metatarsal bone (Fig. 2, *A*). Not infrequently, a claw and one or two phalangeal bones may appear at the point where the hallux should be; occasionally the distal end of the metatarsal bone is also represented, and sometimes a complete digit with all the bones and articulations of a functional hallux may be developed. Such cases, which may be regarded with certainty as reversions to the five-toed type of foot, occur not rarely on the pes of the Scotch collie, St. Bernard and Newfoundland (Fig. 2, *B, C*).

In the foot of the pig the hallux is gone and the pollex is normally represented by a small carpal rudiment (Fig. 3, *C*). A small pollex was, however, present in the manus of *Ancodus*, one of the fossil swine

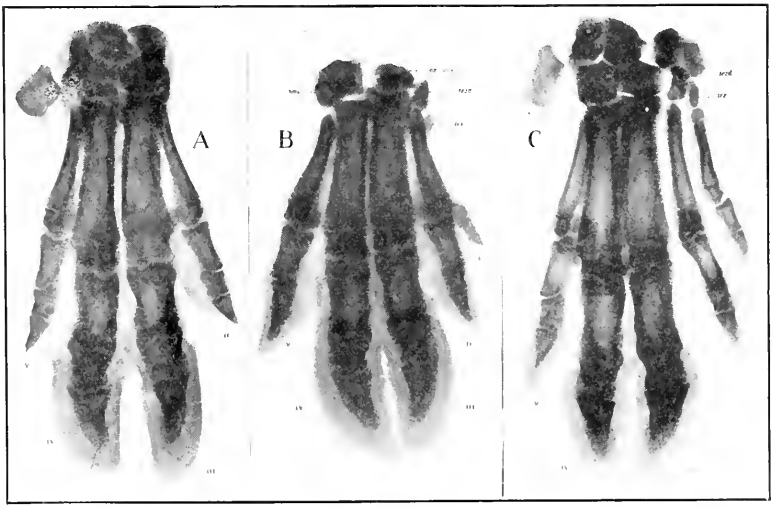


Fig. 4. X-ray photographs of the pig's manus showing normal structure and reversionary polydactylism. *A*, bones of normal manus; *B*, manus in which the pollex is represented by two phalanges and the distal end of the metacarpal bone (I.); *C*, manus with pollex completely developed; *trz.*, trapezium.

(Fig. 3, *A*). It is, therefore, an interesting fact that in the polydactyl swine observed by the writer the extra digits were in every case located upon the manus, and in most instances were undoubtedly developed from the rudiment of the pollex; for the extra digit was attached to the carpal bone as a normal pollex would be, and careful dissections of muscles and nerves gave no evidence of duplications. This does not support Gegenbaur's assertion that the extra digits of swine were developed by the splitting of the second toe. His conclusion was based on the dissection of two 'pig's knuckles' cut off below the carpus. Consequently he could not tell how the extra digit was attached. In any case this was scanty evidence on which to base a general conclusion. The writer was fortunate enough to obtain for study thirty-six perfect specimens. In one type observed, a small hoof, two phalanges and the distal end of the metacarpal bone were developed (Fig. 4, *B*) and in several cases a perfectly formed pollex was present (Fig. 4, *C*). In its general structure the manus of such polydactyl pigs resembles closely that of the fossil swine *Ancodus*, as may be seen by comparing *A* and *B*

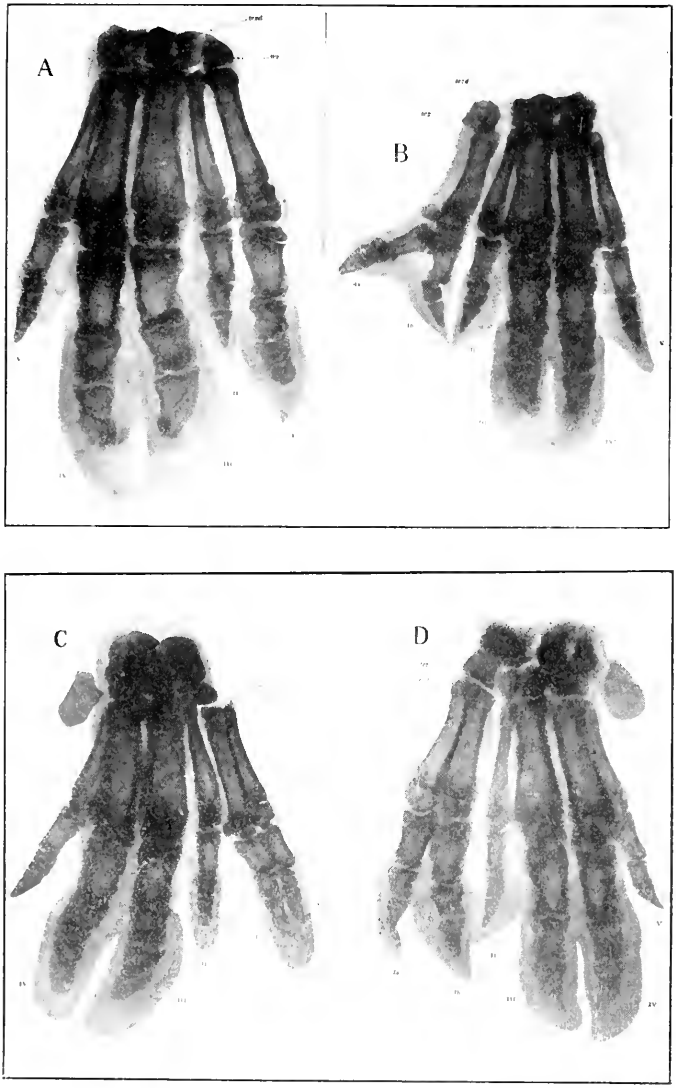


FIG. 5. A series of four X-ray photographs showing variations and duplications of the pollex (I.) in the manus of the pig. *A*, a manus in which the pollex is represented by an abnormally large digit of three phalanges; *B*, the phalanges of the extra digit are duplicated; *C*, all the bones of the extra digit are duplicated, but both sets of phalanges are enclosed within a single hoof; *D*, two extra digits are present, articulating with a single trapezium (*trz.*)

of Fig. 3. In other instances not a pollex, but a digit of three phalanges, was produced, and these in turn exhibited all stages of duplication up to the formation of two large extra toes. But in each case the two extra toes were developed by the variation of the rudimentary pollex (Fig. 5, *A–D*).

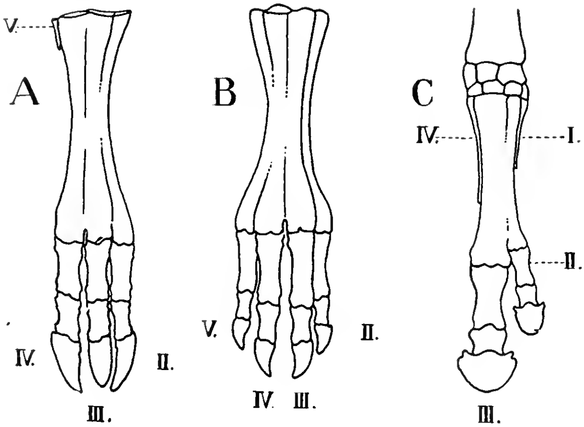


FIG. 6. *A*, calf's manus with digit II. fully developed (from X-ray photograph); *B*, manus of sheep with two extra digits (II. and V.) present (after Chauveau); *C*, manus of horse with two extra digits (I. and II.) (after Marsh).

The writer has also observed two cases in which the second digit of the ox was developed into a functional toe (Fig. 6, *A*), and in the foot of the sheep four complete digits sometimes occur (Fig. 6, *B*). As far back as Roman times the horse is known to have possessed extra toes. Suetonius alludes to a horse given to Julius Cæsar 'which had feet that were almost human, the hoofs being cleft like toes.' Two cases were described by Winter in 1703, and Marsh has since observed the development of an extra digit from one of the splint bones (Fig. 6, *C*); four or five digits may sometimes occur, but all of these are not completely developed.

It is thus clear that the vestiges regarded as digital rudiments are really such, and that mammals possessing these vestiges must at one time have had a greater number of functional toes, some of which later became useless. It is a well-known theory that this reduction in the number of digits was in adaptation to some special function like that of locomotion. It has been carried to the extreme in the foot of the hoofed mammals; and of living forms, the swine and ruminants afford a beautiful series of digital reductions (Fig. 7, *A–H*). Even among living carnivora, forms like the cat and dog have the pollex reduced and the hallux absent, and, as we have seen, the forerunners of the swine had a reduced pollex on the manus (Fig. 7, *A*), and only four digits on the pes. The first digit is vestigial among the hippopotami; the second and fifth are slightly smaller than the third and fourth (Fig. 7, *B*). The difference in the size of the two pairs of digits is more marked in another fossil pig, but the small outer digits still articulate firmly at the wrists and ankle joints (Fig. 7, *C*). The third and fourth toes of the swine are relatively much larger and have taken unto themselves the whole articular surface of the carpus and tarsus (*D*).

Like the pig, the little water-deer (*Dorcatherium*) possesses four distinct functional toes, but in *Tragulus,* a closely related form, the outer toes are exceedingly slender and do not articulate proximally (*E*). The upper ends of these small digits have been reduced in the foot of the roebuck (*Capreolus carea*); in the extremities of the red deer (*Cervus elaphus*), these digits are represented only by the bones of the phalanges and vestiges of the metacarpals and metatarsals (*F*). In the foot of the sheep the outer digits are reduced to two small phalanges (*G*); these are absent in the foot of the ox and the antelope. Finally, the small hoofs, the only vestiges of the second and fifth digits of the ox, disappear in the extremities of the giraffe and the camel (*H*).

This series of extremities thus shows a reduction from five to two digits. The gradual atrophy of these three toes has been ascribed to the specialization of the foot as an organ of rapid locomotion. Primi-

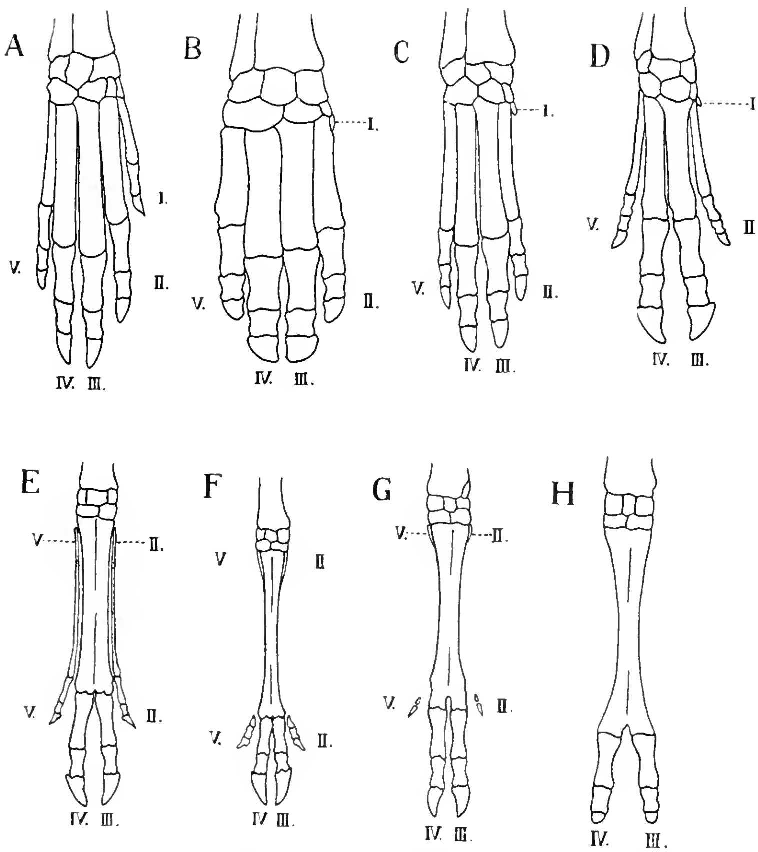


FIG. 7. A series of arterio-dactyl extremities showing successive reduction of the digits from five to two. *A*, *Ancodus* (fossil); *B*, *Hippopotamus*; *C*, *Hyopotamus* (fossil); *D*, *Sus*; *E*, *Tragulus*; *F*, *Cervus*; *G*, *Ovis*; *H*, *Camelus*.

tive mammals were plantigrades, resting the whole surface of the foot upon the ground in running. This posture is not favorable for rapid locomotion, as instanced by the lumbering gait of the bear. It has been retained only by animals which, through burrowing, swimming, climbing or means other than speed are enabled to escape their enemies or obtain their food. But both to beasts of prey and to their quarry increased speed and leaping power would be of great advantage in the struggle for existence. To obtain this advantage they had recourse to the same expedient to which on occasion plantigrade man still resorts —they ran upon their toes. If by variation, the digitigrade position became gradually, or suddenly, the fixed posture of the foot in progression, the structure of the digits would soon be affected. Provided that the feet were used only in locomotion, the shorter digits would not reach the ground. Being useless, they might soon disappear. The reduction of the digits has, therefore, been ascribed simply to the adoption of the digitigrade posture. This is, indeed, the chief, but it is not the only factor. It does not explain why the hallux of the dog and cat has atrophied, while the pollex persists; why the pig and water-deer have four digits, the giraffe and camel only two, though all are digitigrade.

There are evidently three factors upon which the degree of digital reduction depends: (1) the specialization of the extremity for locomotion; (2) the degree of perfection to which the digitigrade posture is carried; (3) the character of the ground which the animals traverse.

The hallux of the dog and cat has been reduced, because the pes is used only for progression and in the digitigrade position. The pollex of these animals has been retained, as the claw is useful to the cats in climbing and in catching their prey—to the dogs and wolves in burrowing and in holding their prey. It is interesting to note that the pollex is no longer a functional organ in the manus of the hyena, an animal which feeds chiefly on carrion.

To the Carnivora, which are beasts of prey, a padded foot and sharp claws are necessary structures. We, therefore, find that the digitigrade posture is not developed to the extreme. These animals run upon the ball of the foot; whatever may be the character of the country traversed, all four toes are used in progression, and no further reductions have taken place.

To the herbivorous ungulates claws are useless structures, and in escaping from their foes noise is no drawback. Speed is their chief requirement and this is increased by leaping from the tips of the toes. This method of progression would blunt the claws, which would then be modified to protect the toes.

If the digitigrade position is not well developed (as is the case with the slow, heavy ungulates like the elephant, tapir and rhinoceros) all the toes, or all but the first, may reach the ground and function in locomotion. But if the digitigrade posture be extreme, the fate of the digits will depend upon the habitat of the animal. Should the region ordinarily traversed offer smooth, firm footing, an animal running upon the tips of its toes would use chiefly the longer third digit; this digit would naturally be strengthened and increased in size, while the other digits, being useless, might gradually disappear. Such changes have taken place in the foot of the horse, and in this way the perissodactyl, or odd-toed, type of foot has arisen. As is well known, the habitat of the horse family is the dry rolling plain, and what evidence we have goes to show that the remote ancestors of the horse ranged a similar country. The fact that the digits of the horse were first reduced at their distal extremities points to the same conclusion. For, as we shall see, digits which do not support the weight of the body, may, if the animal frequents swampy regions, keep the foot from sinking too deeply. In such cases the reduction of the digits begins always at the upper or proximal end, just the reverse of conditions in the foot of the horse. We may conclude then that the odd-toed foot resulted from digitigrade locomotion over firm, comparatively level ground.

For rapid progression over swampy ground, the structure of the foot must conform to two requirements. It must be prevented from sinking too deeply and must be easily withdrawn. Any one who has attempted to walk across a mud flat can appreciate the importance of these two factors. It is in adaptation to these requirements that the artiodactyl, or even-toed, type of foot has evidently been developed. If an ungulate was of semi-aquatic habits, or attached to swampy places, all four digits, by spreading, would prevent the sinking of the foot; its withdrawal would be facilitated by making the foot occupy as little space as possible, and this could be accomplished by shifting the proximal articulations of the outer digits inward and posterior to the middle digits. The toes would then be arranged in pairs, the outer pair lying somewhat behind the other. Now in a semi-aquatic animal each pair of digits would be subjected to the same usage in walking or running through boggy ground: the digits of each pair would tend toward the same structure on this account. But as the middle digits would support the greater part of the strain brought to bear upon the foot, this pair of digits would naturally become larger and stronger than the other. Should our hypothetical ungulate change its habitat from the swamp to the firmer footing of the plain or upland, the outer pair of digits would not reach the ground, and unless they proved of use to the animal in some other way we should expect them to speedily disappear.

This theory as to the origin of the artiodactyl foot is supported when we examine into the habits of the even-toed ungulates. The more primitive forms are attached to the water. The amphibious hippopotamus possesses, as we should expect, four digits, arranged in pairs of equal size. The wild swine, although attached to water and to boggy ground, are nevertheless swift runners, and spend most of their time on more solid footing. The outer digits are retained because they are useful in keeping the foot from sinking in the mud, though they are not functional a good share of the time. The greater strains brought to bear upon the middle digits have resulted in their increased size (by variation) and their monopoly of the carpal and tarsal joints, firm articulation with which is no longer needed by the little-used outer toes. That these changes were advantageous to the swine is shown by the fact that related forms, less adaptive in this respect, have become extinct.

Of the deer family, the water chevrotain and its relatives are the only forms possessing four complete digits. Again we have to do with animals attached to swampy places, and the outer digits, though slender, are retained intact because of the extra support they offer in traversing boggy ground. The fusion of the metacarpal and metatarsal bones of the middle digits, which characterizes the foot of other ruminants, has evidently been prevented in the water deer by the spreading of the toes.

The red deer is one of the swiftest of runners and its usual habitat is the wooded plain and upland. It, however, readily takes to the water, as a large part of its food consists of aquatic plants. In roaming the more solid floor of the forest only the middle digits support the body. These have become relatively larger than those of swine, and are further strengthened by the union of the metacarpal and metatarsal bones. The outer digits are perfectly useless in ordinary locomotion, but still perform two important functions: they serve to support the foot in yielding ground and give the deer a firm footing when running rapidly, especially down-hill. Any one may observe that in walking on fairly firm ground the foot of the deer leaves but two hoof-prints, but that the foot of a running deer leaves four distinct marks. The performance of these functions has caused the retention of the lower portion of the outer toes. But as these digits no longer support any part of the weight of the animal, no proximal articulation is necessary and we find that the upper part of the metacarpal and metatarsal bones has atrophied.

Wild goats and sheep are mountain animals, feeding on rugged and precipitous slopes where the footing is precarious. Both sheep and goats are expert climbers and leapers, but in their ordinary habitat only the middle digits are used for supporting the weight of the body. The outer digits have, therefore, been reduced, but the hoofs and rudiments of two phalanges have been retained, because these small toes are used in climbing, and render the animals more sure-footed. No such function is performed by the second and fifth digits of the antelope, bison and ox; these animals roam the open plain and upland, and the outer toes would be of no use except for the occasional support of the foot when these animals enter the water to drink. We find, therefore, that only the small hoofs of the reduced toes persist. In the foot of the camel and giraffe even these vestiges have disappeared, as their habitat has long been the dry, sandy plain.

From these observations it seems plain that among ungulates the functions of the digits have been affected by the habitat of the various animals; and that there is a direct relation between the degree of digital reduction and the character of the country traversed. The use of the foot as an organ of locomotion alone, and the assumption of the digitigrade posture, were the primary factors producing reductions of the toes; the degree of such reductions and the type of foot produced have been dependent upon the habitat of the animals. The artiodactyl foot was formed in adaptation to semi-aquatic habits, and as the animals changed their habitat to 'terra firma' a further reduction of the digits resulted. The perissodactyl, or odd-toed, type of foot, began with the assumption of the digitigrade posture by animals which traversed solid ground, and the digits were further reduced as the digitigrade posture was developed to perfection.

It has been assumed that those digits which were useless would disappear. There is evidence that if they were not reduced they would be not only useless, but of distinct disadvantage to the animals. The writer has observed that the extra hallux rarely occurs on the pes of hunting dogs; when it does occur it is frequently injured and sometimes completely torn away. It is also noteworthy that the extra toe is most often found on the pes of the St. Bernard and Newfoundland, in which breeds it may be of some use for swimming, and walking through deep snows. It has been observed, too, that the small hoofs of the sheep and deer grow rapidly on the second and fifth digits, but are normally worn away by daily use. If these animals are kept in unnatural surroundings, as when sheep are deprived of rocky pasture, or deer kept in zoological gardens, the hoofs of the reduced digits will grow long, curved and twisted to such an extent as seriously to impede locomotion. We can readily see that should the wild deer or sheep change its habitat to the smooth footing of the open plains, the same abnormal growths might occur and hinder rapid locomotion. Variations tending toward the reduction of these digits would favor the survival of their possessors, and give rise to the type of foot found among the antelopes, cattle and giraffes.

In conclusion it may be of interest to speak briefly of the digital reductions which have taken place in the foot of the running birds (Ratitæ). The most primitive of the birds exhibited the digitigrade posture, but walked upon the ball of the foot. This may have caused the reduction of the fifth digit (which early disappeared), and certainly had to do with the reduction of the hallux. The hallux has, however, been retained by most flying birds because it is used in perching, in prehension and in swimming. As the legs of birds are set well forward on the body, they are more widely separated above than below. This position has thrown the greatest strains upon the outer or fourth digit, which is always longer than the second toe. Now in the foot of running birds like the emu, the digits are used only in locomotion and the hallux has disappeared, as it was useless in progression. But the digitigrade posture of the emu is the same as that of the flying birds; the ball of the foot touches the ground and the remaining three digits, being all functional, are well developed. The ostrich, however, has increased its swiftness by running (and walking) upon the tips of its toes. This posture would throw the weight of the body and the work of locomotion upon the longer third and fourth digits. As the foot of the ostrich is used only in locomotion, and as the birds traverse the smooth floor of the desert, the shorter second digit would fail to reach the ground and eventually disappear. As a result we find that the ostrich has only two functional digits.

The digits of birds, therefore, show structural changes which are exactly paralleled by those exhibited by various ungulates, and the digital reductions which have taken place may be attributed to the same factors in each case.

A SANITARY OUTLOOK[1]

BY SIR JAMES CRICHTON-BROWNE, M.D., LL.D., F.R.S.

ONE of the hopeful signs of the times is the popular interest that is manifested in health questions. No doubt, as Carlyle said, all men are born hypochondriac, and in all ages—never more so than in the present one—swindlers like Caliogstro have driven a thriving trade in well-advertised potions and specifics, but never before has health in the aggregate been the object of public concernment as it now is: never before have the scientific principles that underline its preservation and the practical methods by which these may be applied become, to the same extent as now, part of the civil polity of the nation. The whole country is valetudinarian now, in the best sense of the word, conscious of its weakness, determined to recover its strength. Topics that not long ago would have been thought suitable only for a medical society are discussed in the streets and across the dinner table, while the newspapers teem with articles on physical deterioration, infantile mortality, tuberculosis and cancer research.

And this is, I think, as it should be. The intelligent cooperation of all classes is needed in carrying on the great work of sanitary reform. There should be no squeamish affectation in ignoring subjects that are of vital and universal significance. There is no mystery in physiology and hygiene, and the better these are understood the greater will be the deference paid to expert opinion in matters in which special knowledge is involved, the clearer will be the appreciation of the boundary where prophylaxis terminates and medical diagnosis and treatment begin.

But the inevitability with which all statements bearing on public health are in these days bruited abroad and the avidity with which they are received make it incumbent more than ever on those who speak with authority on such subjects to observe caution and discretion, for doubts or speculations that would be harmless or even stimulating when addressed to a critical and well-informed audience, may become confusing or misleading when, having passed through the alembic of the journalistic mind, they appeal to the general. I had that brought home to me somewhat forcibly on a recent occasion on reading the newspaper reports, just for one day, of the meeting of the British Medical Association at Leicester. I found there an eminent medical authority reported as giving some countenance to telepathy, which I

[1] A paper read before the second London conference of the Sanitary Inspectors' Association.

am sure ninety-nine hundredths of the medical profession regard as an unproven and in its present shape improbable hypothesis, and throwing cold water on the sanatorial treatment of consumption which, I believe the great mass of the medical profession regard as a valuable addition to our means of contending with that malady. Dr. Maudsley deplored the want of sobriety in some medical statements on the popular platform, in consequence of which the public has jumped to the conclusion that because the bacillus has been discovered phthisis is curable, the old notions of its heredity erroneous, the objection to phthisical marriages obsolete, and the right thing to do forthwith to dot the land with sanatoriums for which, he concludes, not more can be said than for sensible treatment before their invention.

Now, I have made and listened to a good many medical statements on popular platforms respecting tuberculosis, but I have never become conscious of the insobriety which has shocked Dr. Maudsley. On every occasion, three factors in the etiology of phthisis—the seed, the soil and the surroundings—have been fully recognized, and while emphasis has been properly laid upon the seed as the primary and essential cause of the disease, due weight has been given to the greater or less resistance of the living tissues in which the seed is sown, and to the more or less favorable nature of the environment during its germination and growth. Dr. Maudsley is the apostle of heredity and of temperament—matters of great moment—but I do not know of any hereditary predisposition or temperamental condition that will make a man proof against a sufficient dose of arsenic or strychnia, and we have no evidence that there is any that will make him immune to a sufficient dose of the tubercle bacillus of sufficient virulence introduced into his system. The resistance, to the implantation of the bacillus and to its spread and propagation, varies greatly. In some habits of body it will scarce take root; in others it springs up rapidly and flourishes luxuriantly, but congeniality of the soil is a very different thing from hereditary transmission, and there is no kind of inherited constitution or temperament in which in the absence of the seed tuberculosis can be developed. The bacillus has its heredity, as well as its animal or human victim, and it is possible that the occasional failure of its attacks may be due, not so much to the stoutness of the resistance offered, as to the feebleness of the assistants, the descendants of an attenuated stock.

Dr. Maudsley says, 'no one thinking clearly ever thought that actual tubercle may be inherited,' but in saying so he must, for a moment, have lost his wonted lucidity of thought, for Professor Bang has demonstrated that the tubercle bacillus has been found in the livers of the new-born calves of tubercular cows. This mode of transmission of the disease is, however, so rare that it may be ignored, and as it is certain that tuberculosis is not handed down as gout and insanity are known to be, it is right that the public should be taught that the old notion of its heredity is erroneous, and that the main thing to be held in view is the avoidance of the pestiferous bacillus. But it is right also that they should be taught—and they have been so taught from all platforms of which I know anything—that the marriage of a person actually laboring under consumption or of two persons belonging to families in which a marked liability to take on consumption has been decisively manifested are imprudent and to be condemned.

The belief for which Dr. Maudsley makes our intemperate platform orators responsible, that phthisis is curable because the tubercle bacillus has been discovered must have been promulgated, if it exists, by persons in a state of complete obfuscation; for every medical tyro knows that phthisis was curable and was cured in many cases long before Koch's enlightening revelation, and that the espial of the bane, did not at once guide us to an efficacious antidote. But surely Dr. Maudsley will not deny that the discovery of the one true cause of the disease puts us in an infinitely better position for circumscribing its ravages, for preventing it, ay, and for curing it than we were before. We know now that it is the outgrowth not of any subtle tendency passed on from generation to generation, but of a fungus which invades the body from without, by certain channels and has a definite life history; which outside the body has certain favorite haunts and may be destroyed by certain agents and inside the body may have its growth encouraged or retarded by certain conditions, which it is in our power to create or modify. Phthisis is still killing upwards of 40,000 persons in England and Wales annually. Tuberculosis in all its forms is killing upwards of 57,000, but the mortality from phthisis and tuberculosis has fallen enormously and is still falling. Twenty years ago—and during that time there can be no question as to improved diagnosis or change in nomenclature vitiating statistical returns—phthisis caused upwards of 49,000 deaths; to-day it is causing only about 40,000 per annum; tuberculosis caused upwards of 20,000 deaths; to-day it is causing not more than 17,000. Twenty years ago the annual death rate from phthisis was 1,827 per million, against 1,203 in 1903; the death rate from other forms of tuberculosis was 567 per million, living against 459 in 1903. In as short a period as twenty years the death rate from phthisis was reduced as much as 25 per cent. Surely these figures justify platform speakers in some degree of exultation if not of insobriety, and warrant them in exhorting the people to persevere in the use of the means which have secured such splendid results, and to supplement these by other means suggested by our new knowledge of the cause of the disease. The reduction in the mortality from phthisis and tuberculosis has been due, we know, to subsoil drainage, and the other great sanitary improvements that have been effected in the last half century, and has taken place in the absence of any special precautions against the dissemination of the seed of the disease. Is it too much to hope that, now that we know this seed and can intercept and destroy it at the shoots by which it is discharged from its culture beds and granaries to be scattered broadcast, we shall be able still further, and more materially to reduce the tuberculosis death rate and the prevalence of the disease? Nay, further, is it too much to hope that by removing those who have contracted the disease from the impoverished, insalubrious and ill-regulated conditions of life that have invited and fostered it and by immersing them in pure air and unpolluted sunlight in restful and hopeful circumstances, with a liberal and well-adjusted diet and under constant skilled medical supervision, so that untoward symptoms are dealt with as they arise and every bodily function is ordered, as far as may be, in the interests of health—and this is what sanatorium treatment consists in—is it too much to hope that we shall thus save many lives that would otherwise be lost, and prolong the days and alleviate the sufferings of those who are beyond hope of permanent recovery? Our sanatoriums in this country have not yet been in existence for a sufficient length of time to allow of the collection of wholly trustworthy statistics, but the returns as far as they go are highly encouraging, and confirmatory of the favorable verdict on sanatorial treatment arrived at by German institutions. Dr. Maudsley, himself, admits that so far the outcome of experience seems to be that many patients who are sent to sanatoriums in the early stage of the disease, recover if they are kept long enough, that most of those in a more advanced stage improve while they are there, frequently relapsing afterwards, and that those who are badly diseased ought not to be sent at all. And this, he calls a modest result. I am disposed to describe it as a result of which we may well feel proud and as one that, if properly presented to the public, should lead to the adoption on a larger scale than hitherto of this system of treatment at that stage of the disease when it may prove so efficacious. The benefits to be derived from sanatorial treatment have perhaps been exaggerated in prospect. It can not altogether supersede other forms of treatment, at high altitudes on sunny littorals, on the veldt, prairie or desert, or by sea voyages; it can not reconstruct a disorganized lung, but to those whose means do not enable them to command the best treatment under private care, and in whom the tubercular lesions are still of limited extent, and leave enough breathing space, it opens up new hopes of restoration to health. Even to the affluent, sanatorial treatment is profitable in the medical discipline it involves. The time may come when science will give us some tuberculin, or serum, or antitoxin, or antiseptic, that will kill the tubercle bacillus in its hidden lair, counter-act its poisonous products, or reinforce the phagocytes in their attacks on it, but meanwhile sanatorial treatment gives expectations of recovery greater than those of any other kind of treatment that is known to us, and it seems to me inexpedient to say anything which may discourage the benevolent from putting it within reach of the poor and needy, or hinder the poor and needy, stricken with tuberculosis, from taking advantage of it. Even if sanatorial treatment were not superior to home treatment in the number of cures it effected, it is still deserving of support because it withdraws, for a time, from their own homes and from places of public resort persons who are jets of deadly dust, and thus diminishes the diffusion of tuberculous disease. And surely even the arrest of the disease, which Dr. Maudsley admits is secured by sanatorial treatment in advanced cases, is worth having. Even a damaged life is sometimes sweet to its possessor and precious to those who hold it dear; and it will be a sad day for humanity when the prolongation of life under all circumstances ceases to be the chief aim of the medical profession, and when euthanasia procured or suffered, is recognized as a justifiable mode of exit from the sick room. But beyond all this, even in hopeless cases, in which no arrest is secured, sanatorial treatment is not without its merits, for all patients who have undergone it return to their homes educated in the procedure that is necessary to make them innocuous to others, and trained how to deal with their infectious expectoration, and thus again the propagation of the disease may be in some measure limited.

But Dr. Maudsley is not only sceptical about sanatorial treatment, but apparently doubtful of the wisdom of any sort of curative treatment in tuberculosis. The ordained function of the bacillus in the universe is, he suggests, to make away with weak humanity. The loss to the community by the death of consumptives is not, he hints, as real as is imagined. "Might not the ultimate cost to the commonwealth," he asks, "be greater, were those persons allowed to go on living and breeding in it." The assumptions here are that consumptives inevitably breed consumptives, and that the tubercle bacillus invariably fastens on weak humanity, and both these assumptions are erroneous. Recent inquiries have shown that the influence of heredity in consumption is not so great as was at one time believed. Dr. Claud Muirhead found, after an elaborate investigation, and with peculiar facilities for arriving at the facts, that out of five hundred and twenty-four cases of death from phthisis, only one hundred and twenty, or 22.89 per cent., presented in their family history distinct evidence of direct phthisical taint, and other 62, or an additional 11.83 per cent., exhibited a suspicious family history of phthisis. That is to say, at the very outside, only 34.72 per cent. of these five hundred and twenty-four persons who died of consumption, exhibited in their family history any evidence of family predisposition to the disease. This percentage accords fairly closely with the published statistics of Dr. Williams and Dr. Cotton, who give, as the result of their investigations into this point, 34 per cent. and 36 per cent., respectively. In an inquiry carried out by Dr. Squire he found that while about 33 per cent. of consumptives present a family history of tuberculosis, statistics give grounds for attributing the disease to occupations and surroundings in by far the greater number of these cases, and place the possible influence of heredity at about 9 per cent. instead of 33 per cent.

It is certain that persons who have recovered from consumption breed perfectly strong and vigorous children, who remain throughout life free from the disease, and it is preposterous to suggest that if we succeeded in saving the lives of the 40,000 persons who die annually of consumption we should have thereby added to the burdens of the community. We should thereby directly and indirectly have secured enormous economic advantages in the productive industry of the persons saved, and in their contributions to the maintenance of those dependent on them. Mr. Baldwin Latham estimates the saving to this country in twenty years, by sanitary work, in funerals avoided, sickness prevented, and wage-earning powers retained, at £267,141,060; and of that huge sum a big slice must go to the credit of tuberculosis.

Then again, vulnerability to consumption does not necessarily imply either bodily or mental weakness. The disease is most fatal in the prime of life, and strikes down, not merely the feeble and incapable, but the strong and vigorous, catching them at some moment of temporary debility. The intellectually gifted seems to be peculiarly susceptible to it, and it has robbed the world of incalculable benefits in the fruits of genius. It is not by any means merely an eliminator of waste material, but a ruthless destroyer of some of the finest elements of our species, and we need have no misgivings in resisting it and in doing our best to extirpate it altogether. The enormous reduction that has taken place in the mortality from consumption has been an unmixed good, and its final disappearance from amongst us, which is not a chimera, but a reasonable anticipation, will be attended by nothing but gain to mankind.

Dr. Maudsley thinks we shall never be able to keep bacilli out of the body. Well, as regards the tubercle bacilli, we mean to try! And his gloomy prognostications in this matter are considerably discounted when we find associated with them some disparagement of antiseptic surgery and of the sterilization of food because, forsooth, there are hundreds of different kinds of bacilli in the human mouth and intestines, and because the nutritive value of certain kinds of food may be reduced by sterilization. Our operating theaters, as they exist to-day, and every kitchen range, are a standing protest against Dr. Maudsley's extraordinary impeachment. Surgeons do somehow succeed in excluding from wounds bacilli of an injurious character in injurious numbers, and a recent experience in Birmingham suggests that the ice-creams there would have been none the worse for sterilization by boiling, even at the sacrifice of the whole of their nutritive and glacial virtues.

I venture to think that Dr. Maudsley has spoken too despondently about the sanatorial treatment of consumption, and I regret the wide publication of his views, because, coming as they do from one so eminent in his profession, they may tend to check a movement of great promise.

In the same newspaper that contained Dr. Maudsley's fling at sanatoriums, I read a report of a discussion on physical deterioration that must, I think, have proved somewhat bewildering to the man in the railway train. Physical deterioration was affirmed and denied; it was traced to education and to the want of education. It was declared to be decimating our infant population and to be non-existent till the age of thirteen. It was ascribed to underfeeding and overfeeding, to cheap sweets and cigarettes, to maternal neglect, paternal drunkenness, and the want of a Minister of Public Health of cabinet rank. I can not pause to reconcile these apparently divergent views, for, of course, they are reconcilable, but there was one statement made so startling that I should like to refer to it more particularly. And that was that 'environment would knock heredity into a cocked hat,' a statement leading to an article in the paper headed 'The Bubble of Heredity Pricked,' which must mean that organic creation has burst up. Now it may be well that there should be a reaction against an extreme and fatalistic belief in the power of ancestral sour grapes to set the children's teeth on edge, but we can not altogether dispense with heredity, and any one who will contemplate a sheep and a cow and a goose and a rabbit, all brought up on the same common, fed on the same grass, and exposed to the same weather, will realize that there are limits to the power of environment. Tremendous are the potentialities pent up in those little particles of protoplasm—the germ and sperm cell. The truth is that heredity lies at the core of things, while environment plays on the surface. Their reciprocal influences may be detected in every living being. Heredity modifies environment, and environment deflects heredity, always within bounds and under some higher authority that controls the two. The plan of the edifice is practically fixed, but its dimensions, stability, symmetry, soundness and adornment, are subject to modification as the building goes on, and must depend largely on the nature of the material supplied and on the character of the builders. Heredity is, in every individual, made up of two convergent hereditary streams, and becomes solid at the center, but has a fluent edge, and it is on that that environment operates. It is of great importance that we should accurately distinguish between these environmental influences that are temporary in their effects and modify the individual or existing generation, and those that are permanent, and, as it were, sink in and modify the race.

It was in connection with the former of these that the contemptuous treatment of heredity at Leicester, to which I have alluded, took place. Dr. William Hall, who has done so much to stir up an active interest in the feeding of school children, impressed by the prompt and striking results he had witnessed by beneficially influencing their food environment, threw discredit on heredity, and not only so, but argued that there is really only one important element in environment, and that is food. He went so far as to say that food altered the whole condition of the individual, and that the children in the slums of our great cities, properly fed, could be reared superior in physique to children reared in better class districts, which, from his own point of view, proved rather too much, for if the slum children when well fed are superior to the better class children, presumably equally well fed, then they must have inherited more vigorous constitutions, or the better class children must be retarded in their development by conditions other than food. Amongst the Jewish children in Leeds, examined by Dr. Hall, who were so much stronger and less rickety than the Gentile children living in the same district, careful feeding may have been, and probably was, the principal factor in their better health and vigor, but there were other factors which should not be ignored. Racial characteristics must count for something. Dr. Hall says that the poor Jew is more self-reliant, temperate, and has a greater power of resisting infectious disease than the poor Gentile. Does he suggest that these traits must also be attributed to feeding? Then the Mosaic law bears on personal hygiene through other channels than that of diet. The Tenth Ward in New York, the population of which consists almost entirely of Russian and Polish Jews, is the most densely populated in the city, both as regards the number of inhabitants to the acre and of tenants to the house, and notwithstanding this the Tenth Ward has the extremely low death rate, for New York, of 17.14, and is surpassed in healthfulness only by two wards out of the twenty-four of the city—one a business, and the other a suburban district. Now this favorable death-rate and general salubrity of the Tenth Ward are not the result of superior economic conditions, or better feeding, for the people are of the very poorest class, but must be credited to cleanliness and that careful observance of domestic sanitation in all its branches, enjoined by Hebraic rule and custom.

No one will underrate the importance of the part played by food in physical development, or the sinister effects of a deficiency of it, especially when growth is going on, in the production of degeneration; but, as Dr. Dawson Williams pointed out, it is going far to say that the whole of the unfitness of the race is attributable to the lack of food. Many other causes contribute to that. A little later Dr. William Hall seemed himself to realize this, for he affirmed that poverty—a very comprehensive term, covering a multitude of evils—is ultimately responsible for the unsatisfactory physique of our people. Luxury has its degenerates as well as poverty, but poverty is the wholesale degenerator, and it is, therefore, I am sure, with immense satisfaction that all we who are interested in the public health have heard that it is the intention of the government to appoint a Royal Commission to inquire into the working of the poor law. It is to be hoped that the deliberations of that commission will lead not only to the adaptation of the poor law to modern social conditions, but to the discovery of efficient methods of dealing with what may be called incipient pauperism, or pauperism in the making, of distinguishing between professional paupers and the widely different classes that are from time to time in need of relief owing to fluctuating economic conditions, sickness, immaturity, or senile decay, and of ensuring that there shall no longer be death or disease due to actual starvation amongst us. If the commission can solve the problems thus indicated, and if at the same time our statesmen can in their wisdom, by free trade, or retaliation, or tariff reform, or colonial preference, or in any other way, secure steady employment to all who are willing to work, we may then feel sure that the golden age will not be long delayed.

But we can not sit with hands folded waiting for the golden age to be conferred by any government or commission. We must strenuously persevere in our endeavors to ameliorate the condition of the people, and this we can best do by improving their environment in the widest sense. It is with environment you are officially concerned, and sure I am that you have already by your up-hill labors in mending it left your stamp on the condition of the people. And, indeed, I am inclined to think if there had been no sanitary science and no sanitary inspectors, the environment in this country would by this time have been pretty nearly empty in certain localities. The right hand of the medical officers of health, and with special functions of your own, you have in a multiplicity of ways promoted that cleanliness which is not inferior to godliness in giving a man length of days in the land. You have sweetened our lives by curbing the offensive cupidity of tradesmen and manufacturers. You have protected us from secret poisoning in our food, on a scale that the Borgia never dreamt of. You have, at no small risk to yourselves, warded off from us contagious, infectious and epidemic diseases, and extinguished sparks of them, which but for you might have become ruinous conflagrations. You have even in certain cases provided us with mortuaries and superintended our burial.

Your duties as sanitary inspectors bring you into intimate contact with the people of all classes; you are better acquainted than any one else with their environmental conditions, and you will, I think, agree with me that of these the one most urgently in need of consideration at this moment is their housing. It would take many addresses to deal with the housing question in all its aspects. It is a large question. We have, on the one hand, men with half a dozen houses of palatial size, standing in broad demesnes, empty for the most part or thinly populated by a retinue of pampered domestics, and we have, on the other hand, half a dozen pinched families huddled into one mean hovel reeking with filthy effluvium. It is, of course, mainly with the hovel-dwellers that sanitary reformers are concerned, and these present difficulties which may well tax their energies for a long time to come. They are everywhere, for from all parts of the country come complaints of over-crowding in wretched dwellings. It is, of course, in the large towns where benevolent enterprise is moving that we hear most of these evils; but they are by no means confined to the great centers of population, in which, however, they are growing at a rate that can no longer be overlooked. Our town population is, as you know, swelling portentously at the expense of the country. Thirty years ago the population of England and Wales was equally divided between town and country, but now three fourths of it are town dwellers, while only one fourth remains on the land, and the cry of the town is 'still they come.' According to the last census, the persons enumerated in urban were to those in rural districts as 335 to 100, whereas ten years previously they were as 250 to 100. The increase in the proportion of the population in urban districts is due partly to the growth of these districts themselves through the absorption of areas which were previously rural, but in a far larger degree to the migration to the towns of country people, and, as the provision of housing accommodation in urban districts has by no means kept pace with their increase of population, overcrowding has thickened and slums have multiplied.

I need not describe to you the state of matters which has resulted—a state of matters in many places deplorable and repulsive. We have in London 300,000 persons living in families of two or more in one-roomed tenements in which privacy and decency are impossible, often without the smallest ray of sunshine summer or winter, with walls and floors in every stage of dirt and decay, with an atmosphere that is stifling and not seldom alive with vermin. Mr. Burns told us that not long ago in Glasgow, where the housing problem is being so vigorously grappled with, there were places where the floors of the houses were let out at a penny or twopence a place so that any one could lie down on his pennyworth, and all huddled together for warmth in a dense mass of struggling humanity till the morning came. "There were," he said, "two places where the only accommodation given was a cord stretched across the room on which, on the payment of a penny, men were entitled to rest their arms and sleep standing." I do not know that in many places things are quite as bad as that, but in all our large towns and in our small towns, too, housing conditions and overcrowding exist that are an outrage on decency and a disgrace to our civilization.

And heavy are the penalties we pay for these housing conditions and this overcrowding in combination with other insanitary influences that appertain to towns! The urban death-rate for England and Wales is 17 per 1,000 living; the rural death-rate is 12.9; the urban infantile death-rate is 165 per 1,000 births, the rural rate is 126. In every city and town with the increasing density of population on square space, there is an increasing general and special mortality at all ages, but particularly under one year, in insanitary areas. Typhoid fever causes a much greater loss of life in the town than in the country. The urban death-rate from pneumonia exceeds the rural by 87 per cent. The mortality from consumption is at the rate of 1,298 per million living in urban districts and of 1,108 in rural districts. Urban areas suffer more severely from cancer than do rural areas. And almost all these diseases, as well as others which I have not mentioned, because they figure less largely as causes of death, are most prevalent in the most densely built parts of the town, and in the most densely populated areas of these parts, and prevail in these areas in proportion to the number of inmates in the houses, of persons per room, and of insanitary dwellings such as back to back houses, stable dwellings, tenement houses, cellar dwellings and flat houses.

That the townsman is shorter lived than the countryman is incontrovertible. Dr. Tatham calculated that in the rural districts of England the average expectation of life at birth is 51.48 years for males and 54.04 for females, whereas in Manchester it is only 28.78 for males and 32.67 for females, which means that each male has to sacrifice 10.48 years or 39 per cent. of his life, and each female 9.82 years or 34 per cent. of her life for the privilege of being born in an urban area. To show the social waste involved in such heavy mortality, it is enough to point out that 100,000 males born in Manchester would be reduced to 62,326, and 100,000 females to 66,325 in five years; while in the healthy districts it would take fifty and forty-eight years respectively to bring about the same reduction. Clearly the concentration of the population produces a prodigious drain on the vitality of the people, another indication of which is supplied by Dr. Shrubshall's observation that town life tends to extinguish the fair-haired Scandinavian and Teutonic elements in our people which are giving way before the brunette elements of southern derivation.

And the pernicious consequences of such concentration are discernible in other directions. The children reared in towns are on the average at all ages, shorter, lighter and of inferior chest-girth when compared with those brought up in the country. They suffer in a larger degree—and in some towns to a very alarming degree—from rickets, decayed teeth, defects of vision, deafness, adenoids, glandular enlargements and affections of the heart and lungs, and again it is demonstrable that all these degenerative changes are more numerous in children living in houses of one or two rooms than in those living in houses with three or more apartments.

I need not proceed with the sanitary indictment against town life as now constituted. Its misdeeds are written in characters unmistakable to any one with half an eye in the pale faces, and stunted and misshapen bodies seen in swarms in slum areas; and are recorded in family Bibles, if such pious mementoes are still in vogue, for Mr. Cantlie, after prolonged and careful search, could not find a single person whose ancestors, from their grandfathers downwards, had been born and bred in London. But I should like to say a word or two about one of the countervailing advantages of town life, which is often insisted on and that is, that by the mobility and stimulus it affords, it encourages that ascent of individuals from the lower to the upper social ranks upon which the salvation of society depends. It is, we are told, the concentration of population in cities which best promotes the process of bringing capable men to the front, and recruits the real aristocracy of ability and character amongst us. And if that is so then we must be content to put up with a good deal of destruction of human vigor, in return for the work done by cities as instruments of natural selection in weeding out the incapable and inefficient and advancing the more capable members of society, and in providing us with intellectual leaders. But is city life likely to accomplish all this?

Professor Karl Pearson, a very thoughtful and cautious anthropologist, has told us that decadence of character and of intelligent leadership is to be noted alike in the British merchant, the professional man and the workman. There is a paucity, he says, not only of the better intelligence to guide, but of the moderate intelligence to be guided. And this he attributes to the fact that the intellectual classes are not reproducing their numbers as they did fifty or a hundred years ago. And in this view Professor Pearson is supported by the Prime Minister, who said at Cambridge last year, that in the case of every man who left the laboring class, and became a member of the middle or wealthier classes, his progeny were likely to be diminished, owing to the fact that marriages are later in that class. The prospect thus presented to us is, it must be admitted, a lugubrious one. The better we educate our people and the greater the facilities we give to boys and girls of ability in the lower classes to rise in life, just by so much shall we deteriorate the race intellectually, for physical characters are not manufactured by school or college, but are bred in the bone, and if our intellectual classes are physically enfeebled by their intellectual exertions, are enervated by wealth and the love of pleasure, or restrained by prudence born of a wrong standard of life, so that they fail to supply us with a due proportion of intellectuals, then progressive decadence is in store for us.

For my own part, however, I am inclined to think that intellectual decadence, if it is upon us, is not altogether due to the causes assigned by Professor Pearson and Mr. Balfour, and is not necessarily destined to deepen as time goes on. In a people like ours, there is always outside the actually intellectual class, a still larger class, potentially intellectual with abilities incompletely evolved, because never called forth, but capable under stress of circumstance of the higher development, just as an ordinary working bee is capable of conversion into a queen by appropriate feeding. This potentially intellectual class, more prolific than the actually intellectual, may make up for its deficiencies and, breeding true or with favorable variations, supply us with intellectual leaders as good as any we have hitherto had.

Then I am quite sure that the educational ladders, provided hitherto to enable children of the humbler class to climb up in the social scale, do not by any means ensure the transference of the intellectuals from the lower to the higher level. They are mounted by the nimble, the quick-witted, the precocious, whose intellectual energies are in many instances soon exhausted, and around the foot of these ladders there remain numbers of children of really finer intellectual power but slower of growth than those who have scrambled up them. We have thus in our humbler or uneducated class, as they are called, a reserve of intellectuals of undiminished fertility, capable of supplying recruits to the intellectual class of the next generation. Many of our finest intellectuals have sprung from the unintellectual class, and genius is generally more or less of a sport.

My own view is that any dearth of ability from which we may be suffering or by which we may be threatened is to be ascribed not so much to the infertility of the cultivated classes as to the artificial production of stupidity in various ways and to the incessant draining from the country, which is the fit and proper breeding place and rearing ground of intellect, of the best elements of our people to be swallowed up, and exterminated or deteriorated in our big towns. We keep nipping off the buds of promise, and if we insist on having lots of green gooseberry tart, we must be content to go with less of ripe gooseberry jam. As Dr. Ogle has said, "the combined effect of the higher mortality of the town and of the constant immigration into it of the pick of the rural population, must clearly be a gradual deterioration of the whole, inasmuch as the more energetic and vigorous members of the community are consumed more rapidly than the rest of the population." "The country community," remarks Professor Ripley, "grows from its own loins; the city community grows almost entirely by immigration." The country community, mentally as well as physically, develops from within. It is conservative, strong, steady, tenacious, and transmits its mental characteristics, little altered, to the next generation. The city community, on the other hand, accretes largely from without. It is progressive, mobile, fickle, of unstable equilibrium, and under the stress of competition, undergoes mental modifications, which (*Pace Weismann*) it passes on to its successors. And the consequences of the increased instability of the city community are patent enough. Insanity and suicide, both essentially characteristic of industrialism, are far more frequent in business centers than in the homes of agriculture. This does not, however, signify that the mental powers are really more active in the one than in the other. The notion, indeed, that the country laborer is duller in intellect than the man of the same class in the town is untenable. "It is a common assumption," says Professor Wright, "that the country-man is of so limited capacity that he makes use of no more than 300 words. What a libel! The number of words in dialects at the most moderate estimate is over one hundred thousand. In Yorkshire alone, I can call to mind 30,000 different words. If we take the whole of the dialects and put them together, as representing the vocabulary of the working class of this country, and exclude from the English dictionary all technical terms and obsolete words, I venture to say that the number of dialect words will far outnumber the words of the dictionary."

And not less untenable than the notion that the agricultural laborer is dull of intellect is the idea that the city urchin is cleverer and better endowed mentally than the little yokel. Some years ago, Mr. Horsfall asked the opinions of the head masters of two large pupil teacher centers on this point. In both centers there were a number of pupil teachers from the schools of a large town and others who had been taught in country schools. "Both the masters said, that though as a rule, the urban young people were at first brighter and quicker, those from the country, in the long run, showed more staying power, and that their knowledge of country things gave them a great advantage over their town comrades." The conclusion of these masters is in complete accord with that which I arrived at a number of years ago. After a comparative examination of some London Board and Scotch Parish Schools, I found the London children much sharper, more vivacious, and, it must be admitted, more attractive in demeanor than the Scotch children, but the latter, although somewhat stolid and awkward, had decidedly more grasp of intellect and more sound knowledge.

The rule seems to be that the mental development of children is hastened by city life, but soon stops short. Up till thirteen or fourteen they are precocious and then come to a standstill. "At its best," says Dr. Stanley Hall, in his work on Adolescence, "metropolitan life is hard on childhood and especially so on pubescents, and children who can not pass those years in the country are robbed of a right of childhood that should be inalienable, and are exposed to many deleterious influences which jeopardize both health and morals."

City life at its best is bad for children, involving as it does early puberty, exciting distraction, superficiality of knowledge, insufficient repose, and the want of the soothing influences that the country affords, and at its worst when it means a tight squeeze in squalid dwellings, poor food, foul air, foul language, contact with vice, and manifold temptations, it is utterly demoralizing. The chief constable of Glasgow who had to report an increase of juvenile crime in that city, notwithstanding the most strenuous efforts of the police to prevent it, informed the Royal Commission on Physical Training that juvenile depravity was regulated to a large extent by the home influence on the child, the period between twelve and fourteen being that when the mind is most susceptible to influence for good or evil. "Amongst the lower class in the city," said Mr. Ross, "of course one finds the children most depraved, the parents or guardians in many cases being criminals of the lowest possible standard. Street trading is undoubtedly a curse to this class of children. It has been proved again and again that the street gamin is second to none in vice and wickedness of every conceivable kind, in fact, he reduces the commission of a crime to a fine art. If, however, he is taken from his evil surroundings and placed in an industrial school or reformatory he, in the majority of cases, turns out a success in life."

The facts and figures I have been quoting represent the city as an instrument of physical, intellectual and moral degradation. They represent it as sucking in the crude vigor and vitality of the country, sophisticating and enfeebling them by its rigorous competition, and ultimately turning them into inefficiency. It seems obvious that if the city goes on growing at the nineteenth-century rate, and under nineteenth-century conditions, it will dry up the reservoirs of strength in the population, and leave an immense proletariat of inferior quality and without commanders.

But the shield we have been examining has another side. Big cities are with us and are likely to remain. They have sprung up in obedience to economic laws, and they contribute to wealth, for production increases with increasing concentration of population, and wealth redounds to the advantage of the whole country. They favor specialization and enable every man to make the best of any talent or skill he may possess. The markets they open up stimulate improvements in agricultural methods, and the industries and commerce they establish conduce to good government and individual liberty. They are the nurseries of the arts and sciences, and as to the evils attending them, on which I have been enlarging, they are not all inherent in their very nature, but are largely accidental concomitants of their mode of growth and the offspring of the ignorance and stupidity of their inhabitants. Many of these are in process of mitigation and I dare say it occurs to you that if you had a free hand in demolishing and reconstructing one of our great cities with, say, the cost of the South African war at your disposal, you could free it from much of the opprobrium in relation to sanitary matters that has hitherto attached to it. But such wholesale remodeling is scarcely practicable, and even were it accomplished, the city would still probably fall short of the country standard of health, even if that standard remained where it is at present and were not raised like that of the city. For as things now are, the country is in many parts guilty of sanitary offences as heinous as those of the towns, and is only saved from their consequences in an equal ratio by the wider elbow-room it affords, and the fresh air and unpolluted sunshine it enjoys by nature's bounty. The last royal commission that reported on rural housings described the conditions under which many agricultural laborers live as 'physically and morally unwholesome and offensive.' A London association that in 1897 conducted a systematic inquiry into the state of 240 country villages with 10,000 dwellings declared that in one half of these villages the cottages were bad, and that in some thirty villages there were cases of gross overcrowding. Mr. Walter Crotch has stated that the result of his own very extensive and searching investigation had been "the discovery of whole villages without a drop of water from end to end; of cottages without even the ordinary conveniences which the law of common decency demands, and of poor people having their homes let while they lay quivering in the throes of death." "Week by week," he goes on, "the most shocking cases of overcrowding are reported in the newspapers, and there can be no doubt that this huddling together of people of both sexes and of all ages in the same room is a source of frightful immorality."

Mr. Clement Edwards said in 1900 that many of the inhabited cottages in the south and west of England were in a hopelessly dilapidated condition with gaping walls and rotting roofs, and were, moreover, terribly overcrowded. Some of the facts he reported were positively revolting in themselves and much worse in their suggestions of inevitable social and moral results. As to sanitation it was non-existent. Miss Constance Cochrane, of the Sanitary Institute, quotes a case in Cambridgeshire, in which eleven members of one family were all sleeping in one room owing to the scarcity of cottages in the village. Private enterprise has failed to furnish anything like adequate accommodation for agricultural laborers, and owing to heartless indifference, indolence or official obstruction—perhaps in some degree also to their own complicated ambiguities—acts of parliament, such as the housing of the working classes act of 1890, have remained practically in abeyance. The result of all this is that lamentable abuses—which perhaps the amending act of 1900 may in some degree remedy—still abound on every hand, and that our scattered hamlets, instead of being idyllic abodes of peace, purity and health, have become hot-beds of discontent, dirt and disease.

But in spite of all this, the country, measured by every standard, remains more salubrious than the town, and, as it is certain to participate in those sanitary improvements which in the progress of medical science and of governmental activity in such matters must come, still further to lower the town death-rate and raise its vital energy, it will probably always maintain its position ahead of the town in salubrity. 'The life of the great city,' said Mr. Henry George, 'is not the natural life of man.' He has an affinity for the open fields, and just as the mortality of city adults must always exceed that of rural adults, on account of the more dangerous nature of town occupations, so must the health of a town population, as a whole, be inferior to that of a country population, because of the more unfavorable nature of its topography. The grouping and close proximity of houses interfere with ingress of sunlight and movement of air, and facilitate the spread of zymotic diseases, which often leave permanent debility and defects behind them. The close agglomeration of numbers of human beings, especially in a state of indigence, is conducive to uncleanliness, and to the generation and diffusion of poisonous exhalations of many kinds. And the larger the grouping, and the closer the proximity and the denser the agglomeration, the greater do the risks become, so that in the interests of humanity there should be some limit to town extension and stringent regulation of town organization. Industry says men must aggregate. sanitary science says they should be permitted to do so only so far as is not incompatible with the welfare of the race, and under well-understood safeguards.

We have been contrasting the merits of town and country from a health point of view, and the conclusion must be that while the country is entitled to the preference of the sanitarian, both are urgently in need of his attentions. Excellent and fruitful work has already been done in both, but much remains to be done, and, as I have already said, the most clamant want of the moment is, it appears to me, the application of remedies to relieve the pressure caused by the increase of population in urban centers.

You are acquainted with the remedies which have been proposed for that state of things, *viz.*, regulations directed against overcrowding; the acquisition of special areas by the authorities for the obligatory rehousing in the same neighborhood of those disturbed under parliamentary powers; and the acquisition by municipalities of vacant land for the construction of suitable dwellings. These are excellent as far as they go, but seem to me to be palliatives rather than remedies. They shift the load a little but do not really lighten it, and it has been, perhaps, the perception of their futility that has been responsible for the half-hearted manner in which they have been applied. Real relief is only to be obtained by establishing an outflow from the center to the circumference, and it is by affording increased facilities of locomotion that this may be done. It is to the new motive power that is now advancing with such giant strides that we must look for the removal of some of our housing embarrassments. Railway extensions, tube railways, surface and subsurface tramways, and motor omnibuses and cycles will inevitably bring into existence a number of new suburbs around our big cities, to which, if the cost of transit be kept low and rents remain modest, many of the poorer classes who are not compelled to live near the factory or shop will resort, all the more readily if a shortening of the working day gives time for the journeys to and fro, and if associations be formed to help them to become the owners of their houses. And to these suburbs, should the cost of transit and the time occupied by it or high rents prove prohibitive to the working classes, the well-to-do will in numbers retreat, making room for their humbler neighbors in the inner circles. It is probable, too, that these new suburbs would in some degree intercept the streams of population that are perpetually flowing into the towns from the country, for statistics show that as regards London, at any rate, immigrants settle mainly in the most outlying parts.

The new suburbs of towns will, of course, always spring up on lines of communication and where facilities are offered for building speculation, and spread out around, but it is to be hoped that they will be taken in hand in time, and means devised to limit their indefinite expansion. Mr. Charles Booth has said that towns advancing, show a noticeable tendency to shoot out tongues like the sun's corona, the intervals between them being filled up later, and it is this filling up of the intervals between them that should, if possible, be prevented. Island-suburbs are well enough, but when they swell out, become continuous, and form a girdle round the parent town, they aggravate its evils, and help to strangle it. It has been proposed that air should be supplied to the center of great cities by mechanical means—by the Shone vacuum system, for example, in connection with tube railways—but infinitely preferable to any such artificial arrangement, necessarily finical and liable to break down, is a liberal scheme of natural ventilation. There should, it seems to me, be maintained, in connection with all great cities, a series of broad avenues converging towards them from all the points of the compass, free from buildings, and covered with vegetation. The parks and open spaces in our cities are called their lungs, but the lungs are not of much use without the windpipe, and the green avenues I suggest would act in that capacity, and allow an inrush of fresh air and the escape of the vitiated air which is always accumulating in cities. These avenues, I have said, should be clothed in vegetation, and to my thinking the preservation of vegetation, not only around our great cities, but throughout the country generally, is becoming a matter of grave import. Sir James Dewar once calculated that a healthy man evolves on the average about 200 pounds of carbon in the form of carbonic acid annually, and as an acre of the best cultivated land fixes annually about 2,200 pounds of carbon, it follows that one acre of land can economize as much carbon as is supplied by eleven persons. The Crystal Palace covers an area of sixteen acres. If the atmosphere had to be kept pure by interior vegetation, without external ventilation, it could not permanently contain more than 365 persons without an increasing aerial contamination. But the vegetation in the large Crystal Palace, this island of ours, is being constantly reduced in amount. Enormous tracts of land once cultivated have been appropriated by highways and railways, and works and habitations, and at the same time there has been an enormous increase in the output of carbonic acid and the demand for oxygen by combustion in the consumption of fuel by manufactures of all kinds and for domestic purposes and by the respiration of animals and human beings. The revivification of the air by home industry is gradually decreasing, and the day may come when we shall be entirely dependent on imported oxygen as well as imported food, and will have to trust to the ocean to dispose of our surplus carbonic acid. At present the air of our large towns and especially those with narrow streets and towering buildings is often a very deleterious compound.

It is to the rise of the suburb—the island suburb—set in a sea of chlorophyll easily accessible, well planned, honestly built, that we must look in the first instance for the removal of some of the afflictions that overcrowding has brought upon us. But the suburbs, while it may do much, can not do everything, and there are other sources of relief, which it is our duty to turn to and to improve. We must take measures to reduce the influx of population into our already congested towns, and to keep on the land those who have been born and brought up on it and to bring back to the land those who have inconsiderately left it. Beyond the city and its satellites, we must afford to those who are weary of the dirt, confinement, dreariness and ugliness of over-crowded quarters, room and opportunity for healthy, moral and physical life. And there are several ways in which this can be done which I can but name. We can create new cities on new sites, with all the advantages and none of the drawbacks of the old ones—garden cities of the type so eloquently and convincingly advocated by Mr. Howard, in which the needs of industry and the needs of humanity will be reconciled. Charles Kingsley in his philanthropic ardor foresaw something of the kind for he dreamt of cities—which should be "a complete interpenetration of city and country, a complete fusion of their different modes of life and a combination of the advantages of both, such as no country in the world has ever seen." And his vision has come to pass. We have Bourneville and Port Sunlight—cheering oases in the industrial desert —and better still we have Letchworth, gradually coming into being, on a broader basis and with greater amplitude of design. Letchworth is still incomplete, but two visits to it have enabled me to appreciate the judicious way in which it has been mapped out, the excellence of all its sanitary arrangements, and the rapid progress it is making. It is full of promise, and it would, it seems to me, be a national calamity should any want of financial support prevent the project in its entirety from being carried to a successful issue. It is to provide for 30,000 inhabitants, and that will not be much of a depletion for congested London, but whenever Letchworth is an accomplished fact, other garden cities will be undertaken. The transference of manufacturing industries to the country is feasible; it has indeed been going on for some time both in this country and America, in the avoidance of high rents and rates, and where suitable sites in the country can be provided with suitable accommodation for workers, with cooperating industries around, and with facilities for obtaining power, industries will congregate and garden cities arise.

Another way in which we can tap our great cities of their clogging superfluities of population, is by establishing in our dominions beyond the sea, land colonies, under some such scheme as that so ably excogitated by Mr. Rider Haggard. There are in our cities crowds of men and women brought up on the land, who have drifted into the city, and tossed about there as social flotsam, miserable failures, who with families of young children would gratefully embrace the chance of returning to conditions such as formed the surroundings of their youth, and of rectifying their own mistakes, by placing their children's feet on the path of prosperity. Such families carefully selected, settled in parties, if possible made up from the same towns at home, in well chosen localities, under skilled and sympathetic management and with necessary financial assistance to start with would undoubtedly do well as have done the indigent settlers at Port Amity, while their removal would clear the air of our towns at home.

But the best of all methods and the most promptly available for checking overcrowding in towns is by improving housing in the country. We are told that the flower of the agricultural class flock to the towns because they dislike the monotony of country life and long for excitement and variety. That is so, no doubt, to a large extent, and perhaps our present system of education is calculated to foster discontent with the peasant's lot, and engender vague ambition, restlessness, and a thirst for rousing stimulants, but I suspect that another contingent of country folk find their way into the towns, not so much attracted by their glamor as repelled by the dingy wretchedness they leave behind them. Agriculture is, after all, the most varied and least monotonous of employments, and could the cottages of the laborers be made wholesome and attractive, and the village life invested with some interest, many who now migrate to the towns would stay at home, and many who are in the towns and have tried them and failed, would be glad to be translated back to the land. I feel sure that many of the laboring class, under the goad of poverty, quit with reluctance the fields they have tilled and cast many a lingering longing look behind at the dilapidated hut that sheltered their childhood. The Anglo-Saxon has always had a deep-rooted attachment to his 'ham' and his 'ton.' Home sickness is not, perhaps, as common as it used to be, but the homing instinct still exists amongst us and is to be diligently kept alive if our race is to avoid disintegration. Nothing has seemed to me to presage the pouring forth of the vial of the seventh angel more imminently than the proposal, seriously made, that all infants at birth should be taken away from their parents and brought up in public institutions, foundlings of the state, a system under which all virtue would forthwith go out of us leaving us mere dry husks of mankind. And nothing has seemed to me more minatory for the future of our empire than the decay—for there is some decay—of home life amongst us. The affluent classes in great numbers voluntarily resign its charms for the luxurious indulgence of the club and restaurant, and the round of pleasure, as it is called: and the poor, through no fault of their own, are in large numbers deprived of them, for it is impossible for the tender associations of the home to evolve in a temporary burrow in a town warren. They have a tenement or lodging, but no home; but a vestige of the old home sentiment is sometimes seen, as Mr. Bray assures us, in the fidelity with which they cling in poverty to some bit of furniture—a table, a chair or clock that has stood the wear and tear of time. But if we are to rescue the submerged tenth and redeem the very poor, we must somehow see that decent homes are provided for them. The finest feelings, the firmest principles are nourished in the home; a genuine man's joys, hopes and ambitions should center in it. Truly did the great poet of my country—who was not only a poet but a deep-seeing social reformer—exclaim:

To make a happy fireside clime,
For weans and wife;
That's the true pathos and sublime
Of human life.

For the want of the 'happy fireside clime' the poor are doubtless themselves often to blame. Of the idleness, thriftlessness and drunkenness that keep them poor and homeless, I need say nothing; these are the theme of daily homilies, but there is a habit they have formed which I think in some degree contributes to their penury and is worth noting, and that is the habit of wandering purposely from place to place—a phase of the *mania errabunda*—as it has been called, which possessed the 'Ancient Mariner' and keeps the tramp and the globe-trotter moving on. Without any valid reason, large numbers of them are constantly changing their abodes, and an enormous sum is spent annually on removals that might be more profitably employed in making the home habitable. Removals are, of course, largely instigated and justified by the search for work or for better surroundings, by growing family requirements and improving circumstances, but beyond all that, they go on, on the large scale, simply to gratify the love of change or in a foolish spirit of rivalry. These poor people keep shifting about in sheer restlessness; having dirtied or damaged one dwelling they pass on to another. A friend of mine in Scotland built some model cottages for his laborers, and on visiting them was surprised to find that the bedrooms upstairs were unoccupied and had been converted into stores for apples, onions and potatoes, while the families were herded together below. On inquiring the reason of this, he was told that these laborers didn't care to have more furniture than they could conveniently move in one cart. This sort of thing is very inimical to home making, for the home is a slow growth, that does not, like Jack's bean stalk, shoot up in one night, but must have time to take root and won't bear frequent transplanting. And it is inimical also to success in life. Mr. Patterson, the master mechanic of the Grand Trunk Railway, says: "I find among the class of workmen that comes from the Old Country, there is a great tendency to run from one situation to another; in fact a number of them seem to have an aversion to permanent employment. This wandering spirit is very detrimental to a man's progress."

But apart from the improvidence and stupidity of the poor themselves, or anything like it, the home is still beyond the reach of many of them and in some districts it is a vanishing quantity. It is for the sanitary and the social reformer to work together to resuscitate the home, to augment the taste for it and make it more and more palatable in town and country.

On some future occasion you will, perhaps, allow me to say something about the town-homes of the poor and to offer a few suggestions in connection with the highly complicated problems they present for our consideration, amongst which suggestions, the not least prominent will be one for the strengthening of your hands. I feel keenly, that if the housing question in towns is to be adequately dealt with the sanitary inspector must have more power in his elbow than he has hitherto had. He must have security of tenure, and I am glad to be able to tell you that the preventive medicine section, over which I presided, at the recent Public Health Congress in London, passed a resolution desiring the council to represent to the government the urgent importance of giving security of tenure to the sanitary inspector, as well as to the medical officer of health. Then, the sanitary inspector must have more effective control over the nuisances he discovers, and the only way to give him that is to make his 'intimations' equivalent to a legal notice. These intimations are, I understand, now often treated as waste paper. There are agents and owners of property, of the baser sort, who delight in thwarting and putting obstacles in the way of sanitary inspectors, and to such gentlemen I should give short shrift, showing no particular indulgence to the slum-owner generally. Dr. Harris, medical officer of Health for Islington, reported lately, that in his district 60,296 visits were last year paid by the sanitary inspectors to 7,133 properties, on an average 8½ visits to each. That indicates, I think, much passive resistance, much waste of energy, much unnecessary maintenance of dangers to health, and I agree with Dr. Harris that in this matter 'Law ought to be brought into line with common sense' without delay.

It is to rural housing, more especially in its relation with the relief of overcrowding in towns, that I had intended to direct your attention to-day, but my excursions into the approaches to that subject have left me only a few minutes in which to touch on it. The main point, however, is—and on that I have already insisted—that by improving our country cottages and adding to them cottages of an approved type, we shall in some degree check the exodus from the country and even set up a back-wash from the towns. And in order that we may do that we must have amended the building by-laws that have been in no small measure answerable for the depopulation of rural districts and for the congested state of towns. That these by-laws require to be overhauled and remodeled, no one who has read Mr. Wilfred Blunt's article in the *Nineteenth Century,* or the speeches made by the members of the deputation that waited on Mr. Walter Long, then president of the Local Government Board in November last, can doubt. The unfortunate clause in the public health act of 1875, providing that poor law districts might declare themselves urban districts and so require powers similar to those exercised in towns, and frame by-laws of their own, has been the source of all the mischief. Under this clause half the rural districts of England have acquired urban powers which, being exercised by persons having for the most part an interest in urbanizing the district—jobbers in residential land ripe for development, tradesmen, contractors and local builders—have been used as an instrument to prevent the erection of dwellings suitable for agricultural laborers and to tie the hands of landowners willing to provide such dwellings. No better example of this can be adduced than Mr. Wilfred Blunt's own case. Having himself experimented with an iron bungalow which he found singularly comfortable and commodious, he directed his estate carpenter to erect on his property in the New Forest where there are no builders' by-laws, two cottages, intending should they prove successful to make them the model for cottage building in Sussex. And highly successful they proved. He found they could be erected at the cost of £130 for a building covering 700 feet area, with a verandah of 240 feet more and an outbuilding containing washhouse and closets—"as snug and sanitary a home as any poor man could wish to inhabit, for there was a fireplace in every room, roof ventilation and ample door and window space."

But when Mr. Wilfred Blunt came to Sussex, where the London building by-laws are in force, there was a lion, and a very fierce lion, in the path. The plan of a cottage was submitted to the rural council and no objection was taken to it until the building materials had been deposited on the ground. Then, however, notice was given that the plan was disapproved by the council as violating the by-law. This notice, Mr. Wilfred Blunt thought it his duty to disregard, and went on with the cottage, which cost £130, and which, with an additional quarter of an acre of land, he could let without loss at 2s. 6d. a week or 1s. a week less than an old cottage it replaced. But alas for rural economy! The builder was summoned for building with other than bricks and mortar, and an action was brought against Mr. Wilfred Blunt, as a result of which a continuing penalty of two shillings a day was inflicted on him until the model cottage was pulled down.

It is clear that a check must be administered to rustic Bumbledom, and a stop put to the application to purely agricultural areas of regulations intended for towns, and which in towns have had an altogether salutary effect in preventing the construction of unsafe and insanitary houses. But I can not go as far as some who have urged that there should be no by-laws in country districts, or that such by-laws should not apply to any new building on a freehold property where such building is more than a given number of yards from other dwellings or past the property of adjacent owners. In regard to sanitary arrangements, by-laws seem to us as necessary in the country as in the town. It is not licence, but reasonable liberty that is wanted; not looseness, but elasticity, and it is to be hoped that this will be realized in the model code of by-laws for rural districts promised by Mr. Walter Long, and in which cottages in certain situations are to be permitted of wood or other material.

A powerful impulse has been given to improvement in country housing by the articles on the subject which have appeared in the *Country Gentleman* and *Spectator*, which have, as by natural magic, invoked the enchanting village at Letchworth, which is now on exhibition, and which I would recommend every sanitary inspector concerned in rural affairs to visit and study diligently. He will there, while enjoying a pleasant picnic, have an instructive lesson, and be able to satisfy himself that a serviceable and comely cottage, in all respects suitable for a laborer or working man and his family, can be built for £150, including builder's profit. He will there see cottages of many different patterns, and built of many different materials, of stone, wood, brick, iron, concrete, cement, steel and plaster in various combinations, and will obtain from the catalogue full information about the price and specifications of each. He will see a marvelous display of ingenuity and contrivance in the fitting in, of domestic requirements and of making the most of next to nothing. No doubt his critical eye will detect flaws here and there, but everywhere he will perceive an intelligent deference to the claims of modern sanitation. The cottages vary greatly; each has an individuality of its own, but sunniness, airiness and coziness characterize almost all of them. They appeal to many tastes, but to no tastes that are vulgar or debased. They are pretty, but their prettiness is subordinate to their utility; they are picturesque, but not pretentious. Simplicity and cleanliness are the dominant ideas, and they are cheap with a cheapness that is unbelievable until they have been actually seen and examined, and compared with the estimates. Think of a detached cottage, well proportioned and artistic in design, with a living room with range 15 ft. 6 in. x 11 ft. 4 in., scullery with bath, hot and cold water, 9 ft. 4 in. x 7 ft. 6 in., three bedrooms 9 ft. high, 13 ft. 1 in. x 9 ft., 13 ft. 4 in. x 9 ft. and 8 ft. 6 in.; with pantry, two cupboards, coal hole, shed for wood, water closet, water laid on, drains connected, rain water butt, floor of scullery and pantry tiled, and say whether it is dear at £150.

There are cottages at Letchworth adapted to different climates, and suitable to different districts according to the different material of which they are constructed. I saw some that I thought would scarcely survive a blast of Boreas on a Scotch hillside, others that could withstand a hurricane; some that would be in place where timber is abundant, others where brick or iron are in the ascendant.

The village at Letchworth, unique in its diversity of cottage contours, planted on a bare common, but in sight of stately elm trees circling a venerable church, and gaudy with many floral dyes and green embroideries, recalls, of course, Mrs. Heman's verse:

The cottage homes of England!
  By thousands on her plains,
They are smiling o'er the silv'ry brooks,
  And round the hamlet fanes.
Through glowing orchards forth they peep,
  Each from its nook of leaves,
And fearless there the lowly sleep
  As the bird beneath their eaves.

They recall that verse, but with a difference, for while Mrs. Heman's cottage homes gave delight to the eye by their rugged and peaceful external beauty, they must have brought anxiety to the soul of the sanitarian who peeped into them by their primitive squalidity. The cottage homes of Letchworth are not less gratifying in their sanitary than in their esthetical aspects, and may be slept in by their lowly inhabitants with a sense of security that the cottagers of a century ago, when typhus and smallpox patrolled the land, where scarcely entitled to feel. These cottages have dealt the death blow to foolish restrictions on country housing . That village leads the way in a new movement to which all sound sanitarians will cordially wish success.

A survey of some of these cottages at Letchworth, so quaintly pretty, so minutely commodious, so hygienically correct, so reasonable in price, suggests that they should have attractions for the well-to-do, not less than for the laboring class. Perched on some beetling cliff or breezy down, bosomed in some bosky dell, or planted in the fields neighboring some quiet hamlet, they would form a delightful week-end or holiday resort for families of moderate means. For children living in London, or other populous city, the seaside town, with the vulgar riot of the sands, is not the place in which their vacations can be most healthfully or profitably spent. They should be brought into living contact with nature, be enabled to form friendships with trees and animals, to pry into the secrets of insects and birds, and taught to take more pleasure in the hedge rows with their 'profuse wealth of unmarketable beauty,' than in the shop windows with their flaunting temptations. The cheap cottage as a holiday-home would create new family affinities, promote the unfolding of faculties that are apt to remain dormant or stunted amongst bricks and mortar, and teach self-help and independence instead of the feeble snobbery that meets every want as it arises by ringing the bell, for I saw no bells, electric or other, in these cottages. It would obviate the apprehensions of infection that are often not unjustifiably felt in taking possession of lodgings or furnished houses at seaside resorts, and elicit taste and ingenuity as no mere hired and temporary residence can do. Its decorative improvement would be a recreation, and the owner would be proud to say of it—'a cheap thing, but mine own.' It is thought sometimes that frequent changes of scene are wholesome and educational for children, and so they are shifted year after year to one watering place after another, which, in so far as they come within their observation, are all very much alike. No doubt a variety of new impressions and world-wonder are valuable, but these should come after childhood is over. The apprenticeship should precede the travels, and for young children it is far better that they should be allowed to wind their affections round some one spot of earth, and slowly to form tender associations which will be sustaining and gladdening to them to the end of their days, than that they should dissipate their interest in sight-seeing, and be pleased with a succession of images as immemorable and unemotional as the figures of the kaleidoscope. The farm house has no doubt many advantages as a holiday retreat, but the cheap cottage, as a family seat and permanent possession, is infinitely superior. I hope that some of my sanitary inspector friends in the large towns may see their way to acquire one in some suitable locality. Of well-selected plan, and with some small attractions and additions such as my sanitary inspector friends will well know how to devise, raising the price somewhat upon that of the Letchworth model, but still leaving it within the category of cheapness, such a dwelling should be a source of health and pleasure, and also a good investment.

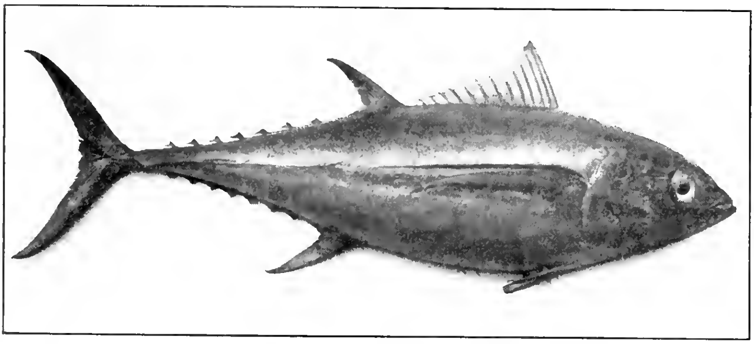
I have taken a wide, a hurried, and, I fear, a somewhat confusing sanitary outlook, but, when I meet you, so many topics in which we are mutually interested press for attention that I am tempted to attempt too much. If at any point in the outlook I have interested you, or suggested to you some new thought, or some new aspect of an old thought, I shall be well content.

SHORTER ARTICLES.

THE YELLOW-FIN ALBACORE IN CALIFORNIA.

Dr. Charles Frederick Holder, of Pasadena, reports that the coast of California has recently been invaded by a splendid new game fish, the Japanese hirenaga or kihada maguro called yellow-fin albacore, *Germo macropterus* (Schlegel). This has appeared in considerable schools off Santa Catalina Island in southern California. I enclose a photograph of a specimen taken near Avalon, sent me by Dr. Holder.

The yellow-fin albacore is common in southern Japan, being often seen in the markets of Nagasaki, where it is conspicuous from the bright yellow color of its dorsal and anal finlets. It is occasionally taken about Hawaii. It is described in the Hawaiian report of Jordan and Evermann as *Germo germo*, with a figure of *Germo germo* (*sibi*) copied from Schlegel's 'Fauna Japonica.' The yellow-fin albacore is, however, distinct from *Germo germo*, and its proper name is *Germo macropterus*, or *Thunnus macropterus*, if we place the long-finned albacores in the same genus as the sunny or tuna (*Thunnus thynnus*).



Yellow-fin Albacore (*Germo Macropterus* Schlegel).

From the related species with long, ribbon-like pectorals, *Germo macropterus* is known by the yellow finlets and by the very high, falcate, soft dorsal and anal fins.

Dr. Holder writes that tuna has almost deserted Santa Catalina for the last three years, owing perhaps to the presence of a school of large and very hungry killers (*Orca*), 'but the yellow-fin albacore, coming so suddenly, gave almost as much sport to the anglers.' The weight of the fish is about fifty pounds.

David Starr Jordan.

THE PROGRESS OF SCIENCE

SAMUEL PIERPONT LANGLEY

In the death of Dr. S. P. Langley, secretary of the Smithsonian Institution, America loses one of its most eminent men of science. Langley was born in Roxbury, Mass., on August 22, 1834, descended from long lines of New England ancestry. As a boy he was interested in astronomy, radiant energy and mechanical flight, and with his brother, now Professor John W. Langley of the Case School of Applied Science, he constructed telescopes. He did not enjoy or suffer a college education, but practised civil engineering and architecture, until, at the age of thirty-one, he became assistant in the Harvard Observatory. In 1866 he went to the U. S. Naval Academy as assistant professor of mathematics, and the following year was made director of the Allegheny Observatory and professor of astronomy and physics in the Western University of Pennsylvania. In 1887 he was appointed assistant secretary of the Smithsonian Institution and succeeded to the secretaryship on the death of Baird the same year. This was then, as it is perhaps still, the most responsible position and the highest honor that can be conferred in this country on a man of science.

Langley made his first published contribution to science at the age of thirty-five, it being a report on the total eclipse of August 7, 1869, observed in Kentucky. In the following year he again observed a solar eclipse, making observations on the coronal rays, and this was followed by his important researches on the solar photosphere. His work on the radiant energy of the sun resulted in and was promoted by the invention of the bolometer, an instrument which has been perfected to measure a millionth of a degree of temperature. This is accomplished by changes of electrical resistance due to heat and detected by a galvanometer, whose fluctuations may be photographed. Some of Langley's most important observations were obtained in 1881 on Mount Whitney at an elevation of 14,000 feet, and they have been continued to the present time in the Astrophysical Observatory, which was in 1891 established in connection with the Smithsonian Institution. Probably Langley's greatest work is connected with the heat of the sun and the infrared rays of the spectrum, but perhaps his researches on aerodynamics are equally well known. His theoretical and experimental contributions to this subject are of fundamental importance, in no wise lessened by the fact that he was unable to solve the practical problem of aerial flight.

Langley died from a stroke of paralysis on February 27. A sketch of his life by Dr. E. S. Holden with a portrait was published in Volume XXVII. of this journal. The frontispiece to the present issue shows Dr. Langley in the robes in which he received the D.C.L. degree from Oxford University. The regents of the Smithsonian Institution have passed the following memorial resolution:

> *Resolved*, That the board of regents of the Smithsonian Institution express their profound sorrow at the death, on February 27, 1906, of Samuel Pierpont Langley, Secretary of the Institution since 1887, and tender to the relatives of Mr. Langley their sincere sympathy in their bereavement.
>
> That in the death of Mr. Langley this Institution has lost a distinguished, efficient and faithful executive officer, under whose administration the international influence of the parent institution has been greatly increased, and by whose personal efforts two important branches of work have been added to its care —the National Zoological Park and the Astrophysical Observatory.

That the scientific world is indebted to Mr. Langley for the invention of important apparatus and instruments of precision, for numerous additions to knowledge, more especially for his epoch-making investigations in solar physics, and for his efforts in placing the important subject of aerial navigation upon a scientific basis.

That all who sought the truth and cultivated science, letters and the fine arts, have lost through his death a co-worker and a sympathizer.

That the executive committee be requested to arrange for a memorial meeting to be held in Washington.

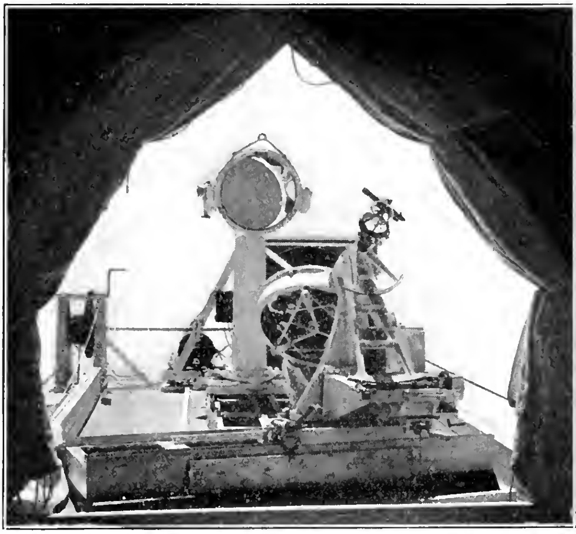
That Dr. Andrew D. White be invited to prepare a suitable memorial which shall form a part of the records of this board.

THE SOLAR OBSERVATORY OF THE CARNEGIE INSTITUTION

Early in its history the Carnegie Institution of Washington showed marked interest in the encouragement of astronomical research. In 1902 Secretary S. P. Langley, of the Smithsonian Institution, recommended the establishment of a lofty solar observatory, for the special purpose of measuring the amount of the solar radiation. In regard to the practical value of such studies Mr. Langley's own words may be quoted: "All the nebulæ in the sky might be blotted out without affecting the price of a laborer's dinner, or the material comfort of a human being. What shall we say of a similar contingency to the sun? While a slight variation in the radiation of the sun may conceivably cause the death of millions of men by famine, it certainly seems worth while to look at it from its utilitarian as well as from its purely scientific interest. It is the possible immense *utility* of the solar observatory that I dwell upon, and concerning which I may borrow the weighty words of Professor Newcomb in a similar connection, and state that astronomical research may bring to light not merely interesting cosmical processes but 'cosmical processes pregnant with the destiny of our race.'" And in another place he says: "Though we may never hope to affect the original source of solar radiation by any human effort, there is every hope that we may learn to forecast its effects upon the earth and provide for them.'

A special committee was appointed to investigate the plan, and, as a result of extended investigations, Mount Wilson, in California, was chosen for a

The Court of the Monastery.



CŒLOSTAT AND SECOND MIRROR OF NEW TELESCOPE.

provisional site, and $10,000 was appropriated for a thorough trial of the mountain. Later the institution decided to undertake the construction and equipment of a solar observatory at this point and up to the present time has devoted more than $300,000 for the purpose. Professor George E. Hale, former director of the Yerkes Observatory, has been made permanent director, and under his care the installation of the observatory has gone forward with characteristic energy. At the present time the Snow horizontal telescope and various buildings necessary for the proper execution of the work of such an observatory are nearing completion. The program of work which Professor Hale has laid out, in a very condensed form, is as follows:

The ends sought are two:

(1) The Study of the Sun as a Typical Star.

(2) The Study of the Sun as the Center of the Solar System.

The investigations include:

I. Direct photography.
   (a) Daily photographs of the Sun on a scale of 6.7 inches.
   (b) Large scale photographs of spots and other regions.

II. Photographic Studies of the Solar Atmosphere with the Spectroheliograph.
   (a) Daily photographs of the Sun taken with H_1, H_2, and $H\delta$, and other dark lines for calcium flocculi and prominences.
   (b) Measurement and discussion of the photographs.

III. Spectroscopic Investigations.
   (a) Daily photographs of spectra of spots.
   (b) A study of velocity of motion of flocculi and prominences.
   (c) Bolometric measurements of relative radiation of sun-spots, faculæ, and photosphere.
   (d) Spectroscopic measurement of solar rotation.

IV. Studies of total solar radiation.

V. Comparative laboratory investigations.

The Snow horizontal telescope is provided with two concave mirrors, one of 60 feet focus, and the other of 145 feet focus, either of which can be used as desired. The beam of sunlight falls first upon a plane mirror of 30 inches diameter, whence it is reflected to a second plane mirror of 24 inches diameter, which sends it to the concave mirror of the telescope. With the image thus obtained any of the pieces of work outlined above may be carried out.

The spectroheliograph is the creation, in large part, of Professor Hale himself, in whose hands it has led to remarkable results. The principles involved seem to have been suggested first by Janssen, but the first practical results were obtained by Hale. The principle of the instrument is simple, but the construction and manipulation of a spectroheliograph which will give the best results calls for the highest skill, while the interpretation of the results obtained taxes the keenest minds. With an ordinary slit spectroscope one may obtain the familiar solar spectrum. Crossing this luminous band are the relatively dark absorption lines characteristic of the various elements found in the solar atmosphere. Each line corresponds to light of a certain wave-length. If now this spectrum is all covered, with the exception of a single line, *e. g.*, the $H\beta$ line of hydrogen, and a photographic plate is placed behind this screen and the spectroscope is moved at right angles to the optical axis, an image of the sun and prominences in monochromatic light is obtained on the plate from successive images of the slit.

With such an apparatus Professor Hale is planning to photograph the sun and prominences each day in various kinds of monochromatic light, one photograph showing a hydrogen sun, another a calcium sun, etc. Recently he has found it possible by setting the slit with special care to obtain photographs of calcium vapor of different densities, and hence at different levels.

Such studies must add greatly to our knowledge of the sun, especially since Mr. Abbot, Dr. Langley's able associate in bolometric determinations of the solar constant, has made a series of observations at Mount Wilson. The original plan for a solar observatory included an elaborate study of the solar constant and any changes in its value, extending over at least one sun-spot period. It was also proposed to have one station at as great an elevation as possible in connection with a lower station, in order to measure the absorption by the earth's atmosphere, and so eliminate it from the determination of the solar constant. To this end an auxiliary station will probably be temporarily occupied on a mountain not far from Mount Wilson at an elevation of some 12,000 feet. Mount Wilson itself has an altitude of 5,886 feet, and overlooks the city of Pasadena, southern California.[1] With the completion of the solar observatory not only will the summit of the mountain make a picturesque sight, with its various instruments and buildings, but from this lofty spot may come much of interest, and perhaps of utility, for the human race.

THE WARREN MUSEUM OF NATURAL HISTORY

The contents of the Warren Museum of Natural History have been acquired by the American Museum of Natural History, New York City. The collection was made by Dr. John C. Warren, who is little more than a name to the present generation, the son of John Warren, first professor of anatomy and surgery at the Harvard Medical School. He became adjunct professor to his father in 1809 and succeeded him in 1815, occupying the chair till 1847, when he retired at the age of sixty-nine. Besides being an eminent surgeon he was an enthusiastic anatomist, comparative as well as human. It is through him that Massachusetts has the honor of having passed the first anatomy law in America in 1831, one year before Great Britain. As a token of consistency he left orders that his body should be dissected and the skeleton kept in the Warren Museum of the Harvard Medical School (not to be confounded with the above-mentioned one). It hangs there to-day. In his later years he found more time to devote to science. In 1848 he was chosen president of the Boston Society of Natural History. In 1852 he published a very handsome monograph on the *Mastodon giganteus*, the finest specimen of which is the centerpiece of this collection.

[1] During the years 1889 and 1890 a temporary astronomical station was maintained at the summit by the Harvard College Observatory.

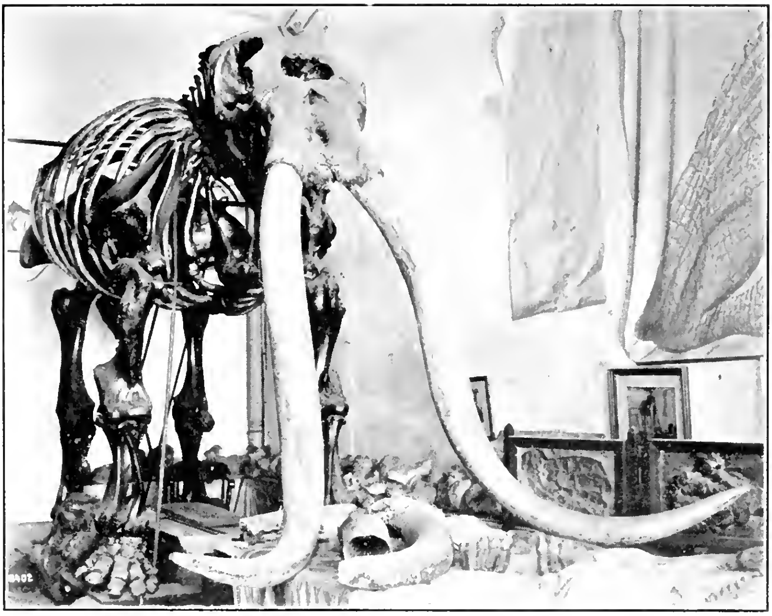


FIG. 1. RESTORATION OF THE WARREN MASTODON.

The history of the 'Warren Mastodon,' found near Newburgh, N. Y., is briefly as follows: In the very dry summer of 1845 diggers in a swamp, the bottom of which had never been seen above water, came upon the head two or three feet below the surface towards evening on August 12. The next day they unearthed the head and then, working backwards, the spine and ribs with the pelvis. While the head was being raised, one tusk parted near the middle and the other cracked at about a similar point, but did not then come to pieces. The feet of the hind legs were found near the shoulders (Fig. 2), showing clearly that the animal had been mired. On the second night the walls of the excavation caved in, covering and disturbing the unearthed parts. This is probably the reason that the end of the tail and many of the last phalanges are missing. Fig. 2 is a photograph of the vignette in Dr. Warren's monograph. Beside giving a view of the country it represents diagrammatically the geological formation. The tree is growing on the very edge of the section. Just below it is a dark layer of peat, followed by a shallower layer of red moss. Then comes one of shell marl in which reposed the more superficial part of the body and the right fore-limb. The rest lay in mud, apparently contained in a cavity formed by clay, which in the diagram descends obliquely on the reader's right. The skeleton was mounted after a fashion and exhibited about the country for some months, when it was purchased by Dr. Warren and mounted anew by Dr. N. B. Shurtleff. The great tusks were unable to support themselves and were replaced by imitation ones, the fragments being preserved. The small tusk of the lower jaw was preserved also, and it is hoped will be found in some safe place in the museum, but its whereabouts is at present unknown. Many, if not all of the terminal phalanges and perhaps a yard of the tail are false, as is also a part of the breastbone, which was broken, probably by the cave-in. Otherwise the skeleton is perfect and the finest in existence. The skeleton of the

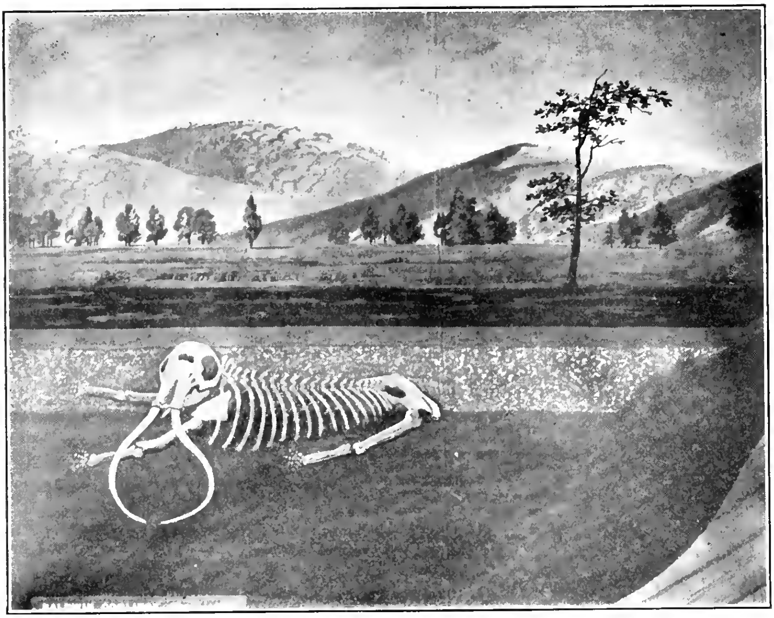


FIG. 2. IMAGINARY SECTION, showing the geological formation at Newburgh, N. Y., in which the Warren Mastodon was found.

elephant 'Pizarro' seems insignificant as it stands beside the mastodon in the brick and iron building in which Dr. Warren placed his treasures of natural history. The collection is particularly rich in mastodon remains. There is the 'Shawangunk' head, which is even larger than that of the Warren mastodon. There are many disarticulated bones of the 'Baltimore' mastodon, as well as many mastodon and mammoth teeth. The vertebræ with fragments of the head of a great zeuglodon, a fossil whale are arranged round the room. A noteworthy feature is the collection of large and small slabs of remarkably fine fossil foot-prints from the Connecticut River valley. Space allows no mention of many casts of fossil remains, still less of mere curios.

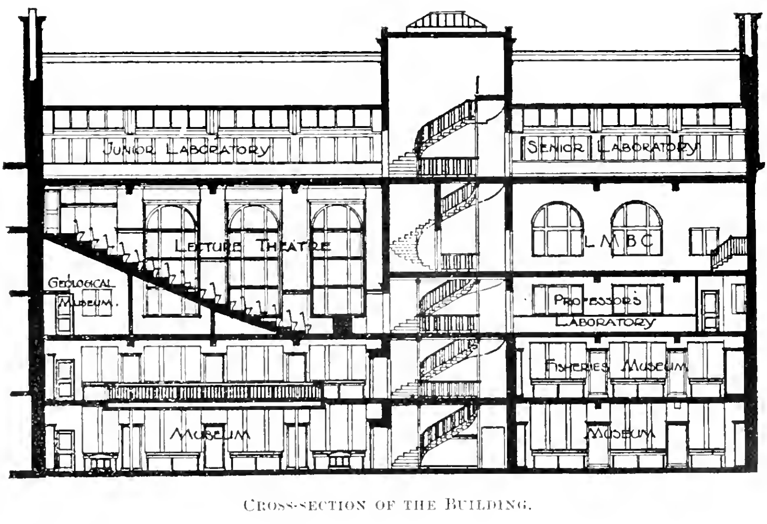
THE NEW ZOOLOGICAL MUSEUM AND LABORATORIES OF THE UNIVERSITY OF LIVERPOOL

THE most significant movement of higher education in England is the development of the newer universities. While Oxford and Cambridge have voted to admit no students without an examination in Greek, the University of London and the provincial universities are paying increased attention to scientific education and research. All these institutions are of late foundation, and they have only recently assumed the name and functions of universities. University College, Liverpool, opened in 1882, has only within the past two or three years assumed the name of the University of Liverpool. A few words in regard to the new zoological laboratories, opened on November 18, will call attention to the progress of the university.

The accompanying illustration shows the new building for zoology, with the adjoining Hartley Botanical Laboratory and the building for electrical engineering. A cross-section of the building for the zoological laboratories is also given. It has a frontage of 123 feet, is 41 feet in depth and 84 feet in

THE ZOOLOGICAL LABORATORIES OF THE UNIVERSITY OF LIVERPOOL.

height from the street level, and is built of red pressed brick relieved with white sandstone. The building consists of a central tower containing the entrance hall and staircase and some of the smaller rooms on each floor, and of two blocks, the north and the south, which have been treated rather differently as regards internal structure. The south block has only three main floors while the north has five in the same height. The central tower extends a story higher. In the south block the three floors accommodate (1) the museum with its large gallery, (2) the lecture theater and (3) the large junior laboratory at the top of the building. In the north block, on the



CROSS-SECTION OF THE BUILDING.

two lower floors there are extensions of the museum to receive special collections, and the rest of the space is devoted to the senior class-room, senior and honors students' laboratories, the departmental library, and rather large laboratory and storeroom accommodation for the sea-fisheries department, the work of the economic entomologist, of the marine biological committee and other practical applications of zoology.

The department of zoology is under the direction of Dr. W. A. Herdman, who was appointed to the Derby chair of natural history at the opening of the college. He is well known for his zoological researches, especially in marine biology. Readers of this journal will remember with interest two articles contributed by him—one on the Naples Zoological Station, the other on the pearl fisheries of Ceylon. Dr. Herdman has not only made the University of Liverpool a center for zoological research, but has developed in connection with it a marine biological laboratory on the Isle of Man.

SCIENTIFIC ITEMS

Rear Admiral Colby M. Chester, superintendent of the U. S. Naval Observatory, was placed on the retired list on February 28. He will be retained in temporary active duty in the Bureau of Navigation. Rear Admiral Chester will be succeeded in charge of the Naval Observatory by Rear Admiral Asa Walker.

Professor A. A. Michelson, of the University of Chicago, and Professor F. Kohlrausch, of Berlin, have been elected honorary fellows of the Physical Society of London.—Sir William Crookes has been elected a corresponding member of the physical section of the Paris Academy of Sciences in succession to the late M. Bichat.—Professor J. J. Thomson, of Cambridge; Mr. Oliver Heaviside, of London; M. Henri Becquerel, of Paris, and Professor P. Zeeman, of Amsterdam, were made honorary doctors of the University of Göttingen, on the occasion of the dedication of the new physical laboratory.

The fiftieth anniversary of the connection of Professor Frederic Ward Putnam with Harvard University has been celebrated by the presentation of a volume, containing autograph greetings from forty of his former students. Dr. H. C. Bumpus, director of the American Museum of Natural History, has been authorized by President Jesup to offer Professor Putnam ethnological material sufficient to illustrate fully the life of the inhabitants of the Philippine Islands, leaving him to make such disposition of the collection as he may think best.—At a meeting held at the Mansion House, London, on February 27, to celebrate the fiftieth year of the foundation of the coal-tar color industry, and to take steps to do honor to Dr. W. H. Perkin, the founder, it was decided that an appeal be made for subscriptions for the purpose of carrying out the following objects: (1) The presentation to Dr. Perkin for his life time of an oil portrait of himself, the portrait to become the property of the nation at his death. (2) The execution of a marble bust of Dr. Perkin to be placed in the rooms of the Chemical Society. (3) The establishment of a 'Perkin Research Fund' for the promotion of chemical research to be administered through the Chemical Society.

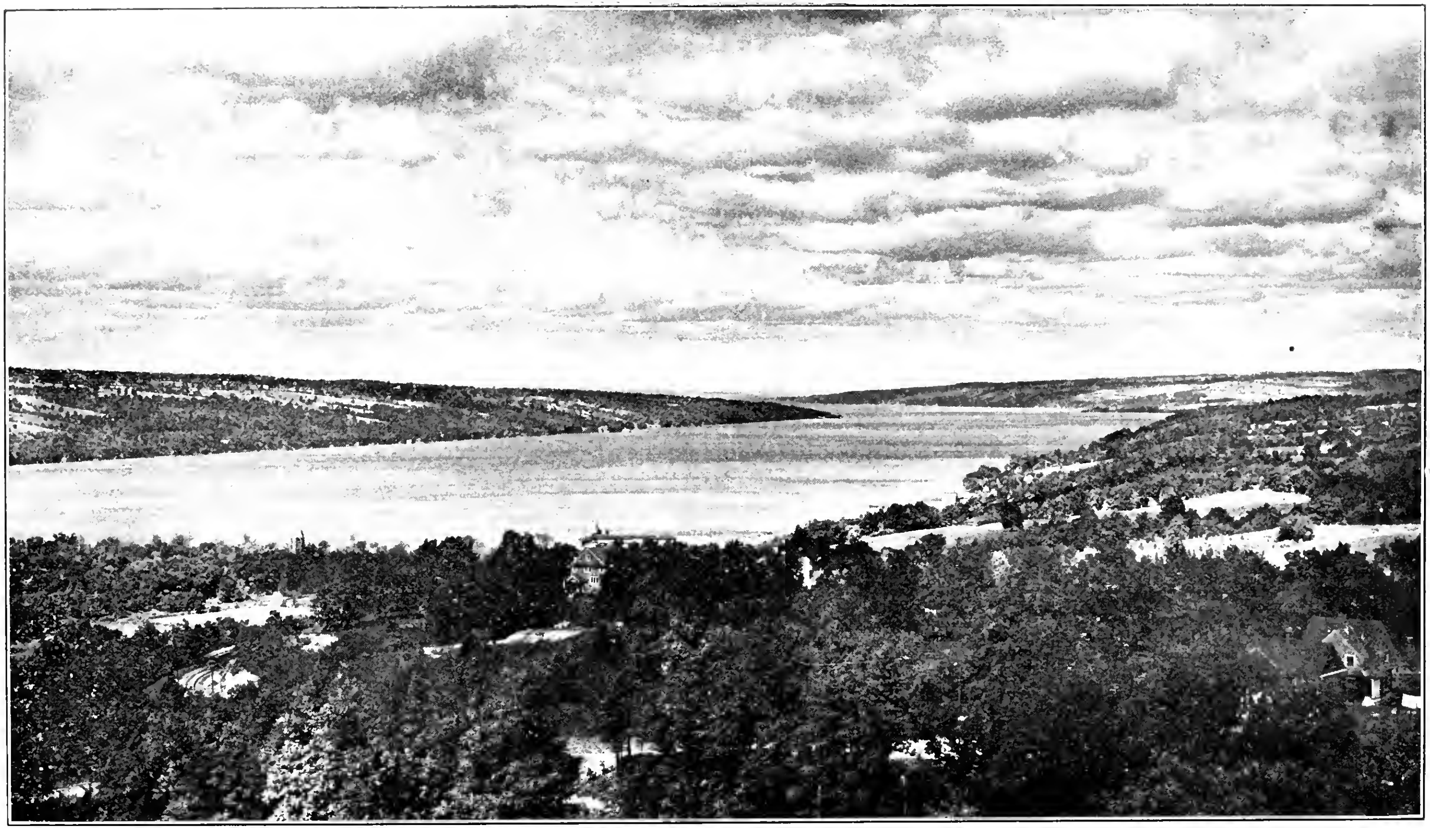


Fig. 3. Cayuga Lake, one of the Finger Lakes, from the Cornell University Campus.

THE
POPULAR SCIENCE
MONTHLY

MAY, 1906

WATKINS GLEN AND OTHER GORGES OF THE FINGER LAKE REGION OF CENTRAL NEW YORK[1]

By Professor RALPH S. TARR
CORNELL UNIVERSITY

FOR some years there has been an effort made to induce the legislature of the state of New York to set aside Watkins Glen as a state reserve for the benefit of the public. As one of the most beautiful and most widely known bits of natural scenery in the state, it seems

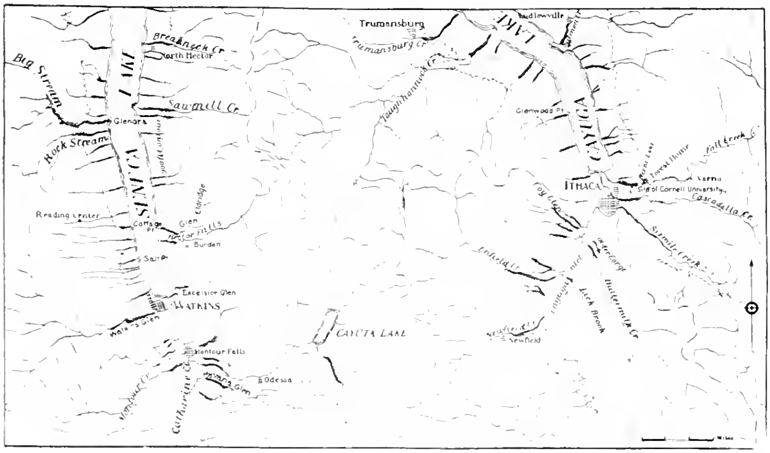


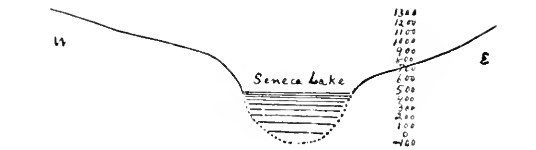
Fig. 1 Sketch Map of the Southern Ends of the Cayuga and Seneca Valleys, Showing the Location of some of the Gorges.

to many of the lovers of this spot that the legislature should take the necessary action for securing the glen as a public park; and there now appears to be reason for hoping that this will be done during the present session of the legislature.

[1] Published by permission of the director of the U. S. Geological Survey.

FIG. 2. PHOTOGRAPH OF MODEL OF ITHACA SHEET. (BY WILLIAM STRANAHAN.)

Watkins Glen is but one of a great number—certainly many scores, and probably hundreds—of picturesque gorges in southern central New York, many of them unnamed, and the great majority known only to a few. They lie in the southern half of the Finger Lake valleys, notably Seneca and Cayuga (Fig. 1), cut in the slopes of the valleys which enclose these lakes. Such an abundance of gorges and associated waterfalls, more than can be found in equal area in any other part of eastern United States, is noteworthy, and seems to demand an unusual explanation, which in fact is the case. This explanation has been worked out step by step, being far more complex than at first supposed, and involving the operation of geological agencies now no



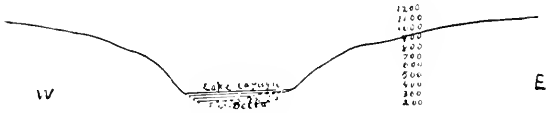


FIG. 4. CROSS SECTION OF SENECA LAKE, three miles north of Watkins. (Horizontal scale ½ inch to the mile; vertical scale, ½ inch to 1000 feet. Column of figures gives elevations in feet with reference to sea-level.)

FIG. 5. CROSS SECTION OF LAKE CAYUGA VALLEY, two miles north of Ithaca. (Scale same as Fig. 4.)

longer present. To state this explanation calls for a preliminary consideration of the general topography.

The Finger Lake valleys extend nearly north and south, long and narrow, like so many fingers, the two longest, Cayuga and Seneca, being about forty miles in length, and at the lake surface from one to three miles in width. Their bottoms are below sea-level. They are excavated in the plateau of southern New York, a dissected plateau of nearly horizontal Devonian shales and sandstones, trenched by many deep valleys (Fig. 2). But among these valleys those of the Finger Lakes stand out prominently because of certain notable peculiarities.

If one of the upland valleys of the plateau should be dammed so as to contain a lake as deep as Cayuga (435 feet) or Seneca Lake (618 feet), or even one a hundred feet in depth, its shore-line would be very irregular, and its waters would extend as bays up the tributary valleys. But in the Finger Lakes this is not the case. The lake shores are smooth and regular (Fig. 3), and this condition extends for several hundred feet above the lake level. The valley walls enclosing the lakes are gullied only by the narrow gorges which are so abundant (Fig. 1). Not only are they smooth and regular, but they are steepened below the 900-foot contour line (Figs. 2 and 3), so that a profile of the valley slope shows a distinct increase in the steepness of the valley wall below that level (Figs. 4 and 5).

At the upper level of the steepened slope, upland valleys open out and lead back into the plateau, so that if the lake waters could be raised 500 feet higher than the present, they would enter into these tributary valleys and the lake shore line would become very irregular, as is natural in a stream valley dammed so as to hold a lake. These upland tributary valleys are broad and mature, having evidently required a long period for their formation; and their counterpart appears throughout the plateau region. They are the normal valleys of the region; the Finger Lake valleys the abnormal.

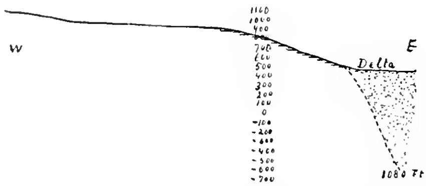


FIG. 6. PROFILE OF CASCADILLA CREEK, which descends the valley side at Ithaca, on the southern boundary of Cornell University campus. (Same scale as Fig. 4.)

FIG. 7. PROFILE ALONG WATKINS GLEN, IN SENECA VALLEY. (Same scale as Fig. 4.)

A significant view of these tributary valleys is obtained from the opposite main valley slope at such an elevation as to permit a view into them. Such a view shows that the broad valleys extend back into the upland, receiving numerous tributaries at the proper grade, and that these valleys are commonly enclosed between moderately sloping walls which flare apart as the lake valley is approached; but all this ends at about the 900-foot level, and the open mouth of the tributary valley is left hanging high above the main valley bottom on the edge of the smooth, steepened slope of the main valley. There the stream leaves its broad upland valley and plunges down the steepened main valley slope, into which it has sunk itself in a narrow and relatively shallow gorge, through which it leaps in a series of cascades and waterfalls.

Normally a tributary stream joins its main stream at an accordant grade, even in such a case as the Colorado River, where the main stream is rapidly deepening its valley. So general is this condition that a stream is ordinarily supposed to decrease in grade from headwaters to mouth at a fairly regular rate; and most streams follow this law. But here there is a normal decrease in grade up to a certain level, then an abrupt increase. Glen Creek, for example, which has formed Watkins Glen, descends at the rate of about a hundred feet to the mile for four miles, then falls in a succession of cascades four hundred feet in a single mile (Fig. 7). This change in grade accompanies a change from a broad, upper valley, over its lip into a narrow gorge cut in the smooth, steepened slope of the lake valley; and the same change occurs in the other streams of the southern half of Seneca and Cayuga valleys (Figs. 1, 2 and 6).

While the condition of smoothed, steepened main valley slopes and associated hanging tributary valleys is abnormal, it is not uncommon. It occurs in the fiords of Norway, New Zealand and Alaska; in the valleys of the Alps. Rockies and Sierra Nevada; and associated with it is a condition of gorges and falls below the lips of the hanging valleys. It is a notable fact that these regions, like that of the Finger Lakes, are regions formerly occupied by powerful glaciers; and it is even more noteworthy that hanging valleys and associated steepened, straightened main valley walls are practically absent in regions not formerly occupied by glaciers.[2] So general is this association; so like the work of ice erosion, as we conceive it, is the anomalous valley form; and so unlike is it to the valleys of stream erosion origin, that physiographers are now quite generally agreed that the hanging valley and the broadened and straightened main valley are the result of glacial erosion.

There are still some who question this conclusion, but none of them has offered a satisfactory substitute or advanced a vital objection to the ice erosion explanation. It is a relatively new point in interpretation of land sculpturing and naturally is not universally accepted at the start. The same was true when the origin of ordinary valleys by stream erosion was proposed in place of the current explanation of catastrophes. In fact, some of the most ardent supporters of the ice-erosion theory are recent converts to it.

When the hanging valleys of the Finger Lake region were first recognized, and ice erosion proposed in explanation of them and of the main lake valleys,[3] there were few who accepted the conclusions advanced; but now the great majority of American physiographers accept the ice erosion explanation for this region, as well as for others. The literature of glacial erosion is now extensive, and the fact of profound ice erosion in valleys freely followed by glaciers seems established; but it would be aside from the purpose of this paper to state the full argument for glacial erosion, which, in fact, others have already done. Suffice it to say that glacial erosion will explain the conditions in the Finger Lake valleys, and no other theory so far proposed will do so. Moreover, these valleys were a highway for glacial motion, as is proved by the presence of pronounced moraines along their sides and at their heads.[4]

When the glacial erosion theory was first applied to these valleys it was supposed that the erosion was simple and of a single period; but the discovery of other facts led first to a question whether some other explanation than ice erosion might not be necessary,[5] and later to the

[2] This statement ought perhaps to be slightly qualified, since exceptional instances of hanging valleys have been described from such regions where other causes, such as marine erosion and faulting, account for the hanging valleys.

[3] Lincoln, *Amer. Jour. Sci.*, Vol. XLIV., 1892, pp. 290–293; Tarr, *Bull. Geol. Soc. Amer.*, Vol. V., 1894, pp. 339–356.

[4] Tarr, *Bull. Geol. Soc. Amer.*, Vol. XVI., 1905, pp. 215–228.

[5] Tarr, *Amer. Geol.*, Vol. XXXIII., 1904, pp. 271–291.

conclusion that the phenomena are the result of a double period of ice erosion.[6]

Of these facts the most important was the discovery of a series of buried gorges on the steepened slope in close association with the postglacial gorges or glens. In some cases the present stream has reoccupied these older gorges; in others it crosses them or follows them for only short distances. They are both broader and deeper than the postglacial gorges, and therefore required a longer period for their formation than has elapsed since the last ice recession. Being occupied by drift deposits of the last, or Wisconsin, ice advance, these gorges were evidently formed before the oncoming of this ice invasion. At first it was uncertain whether these gorges were of interglacial or preglacial age, though the former was strongly suspected.

A definite step toward the solution of the problem was made when it was discovered that in the Seneca Lake valley these older gorges do not extend below lake level. This is proved with especial definiteness on the western side of the Seneca valley, where for many miles there is a continuous rock outcrop along the shore just above lake level, and extending continuously across areas down which the older gorges must have passed. Watkins Glen illustrates this. The older, buried gorge leaves the Glen Creek valley just above the head of the postglacial glen a hundred yards or more above the point where the bridge of the Pennsylvania Division of the New York Central Railroad crosses the glen. It passes under the railway station and down the steepened main-valley slope under the sanitarium, its position there being indicated by a moderate sag in the hillslope, and, still better, by well borings at the sanitarium. Two wells, one at the sanitarium, the other a short distance west of it, fail to reach rock at 105 and 175 feet, respectively; but to both the north and the south of these wells rock is reached at depths of ten to twenty feet, proving the presence of a buried gorge. Below the sanitarium, along the line of this buried gorge, continuous rock outcrops occur, proving that the gorge is not continued there.

These facts prove that the buried gorges are also hanging, at Watkins fully 1,100 feet above the rock floor of the main valley.[7] The interpretation placed upon these facts is as follows: Before the glacial period there was a system of mature drainage, with main valleys along the axes of Seneca and Cayuga Lakes, and with tributaries entering them at grade at the level of the mouths of the hanging valleys, that is, at elevations of about 900 feet above present sea-level. The advent of

[6] Tarr, *Jour. Geol.*, Vol. XIV., 1906, pp. 18–21.

[7] A deep well at Watkins, 1,080 feet in depth, did not reach the rock bottom of the valley, striking the side of a cliff and bending the tool so that further boring was impossible.

the continental glacier buried this land beneath ice, which moved with especial freedom through the north-south valleys, scouring them and leaving them both broader and deeper. The amount of deepening by this ice invasion was at least five hundred feet, and probably much more, the exact amount being impossible of determination at present, since much of the evidence was erased by later ice erosion. Moreover, the first ice advance may have left lakes in the valleys, whose surfaces acted as temporary base-levels, below which the interglacial gorges could not be cut.

With the recession of this ice sheet, the upland tributaries were left hanging five hundred feet or more above the overdeepened main-valley bottom, and the streams descending the steepened main-valley slope began to cut gorges in it. This condition lasted through interglacial times and resulted in the production of fairly broad and deep gorges. Then came a readvance of the ice, which again broadened and deepened the valleys and on its recession left the interglacial gorges, partly buried and erased, hanging high above the newly made bottom of the main valley. Since the retreat of the Wisconsin ice sheet the streams have been engaged again in gorge cutting on the steepened slope, in some places along the lines of the older gorges, but more commonly partly or completely independent of them.

There are some facts which indicate possible greater complexity of ice erosion, for in some of the valleys there is apparently more than one buried gorge; but the evidence on this point is not as yet convincing, and for the present we can point with certainty to no greater complexity than that of two periods, one the Wisconsin, the other of some one of the earlier ice advances with which the work of the glacial geologists of the Mississippi valley have made us familiar.

The various glens of the Cayuga and Seneca Lake valleys, whose general cause is as above stated, differ greatly in detail. They are all wild and picturesque, and they are all narrow gorges with many cascades and waterfalls. Their variations depend upon the varying combinations of effects from several causes. One of these is the influence of the buried gorges. Wherever the postglacial stream enters one of these its valley abruptly broadens. Where the postglacial course coincides with the buried gorge the expansion is continuous; but where it merely crosses the older gorge, the narrow rock-walled and rock-bottomed postglacial gorge is replaced by an expansion, forming an 'amphitheater' with drift walls and bottom. The valley again contracts where the stream leaves the buried gorge and has cut a postglacial glen in the rock of the other wall of the older gorge.

A second cause for differences in the gorges is the influence of the variation in resistance to erosion of the nearly horizontal strata of Devonian shales and sandstones in which the gorges are cut. The

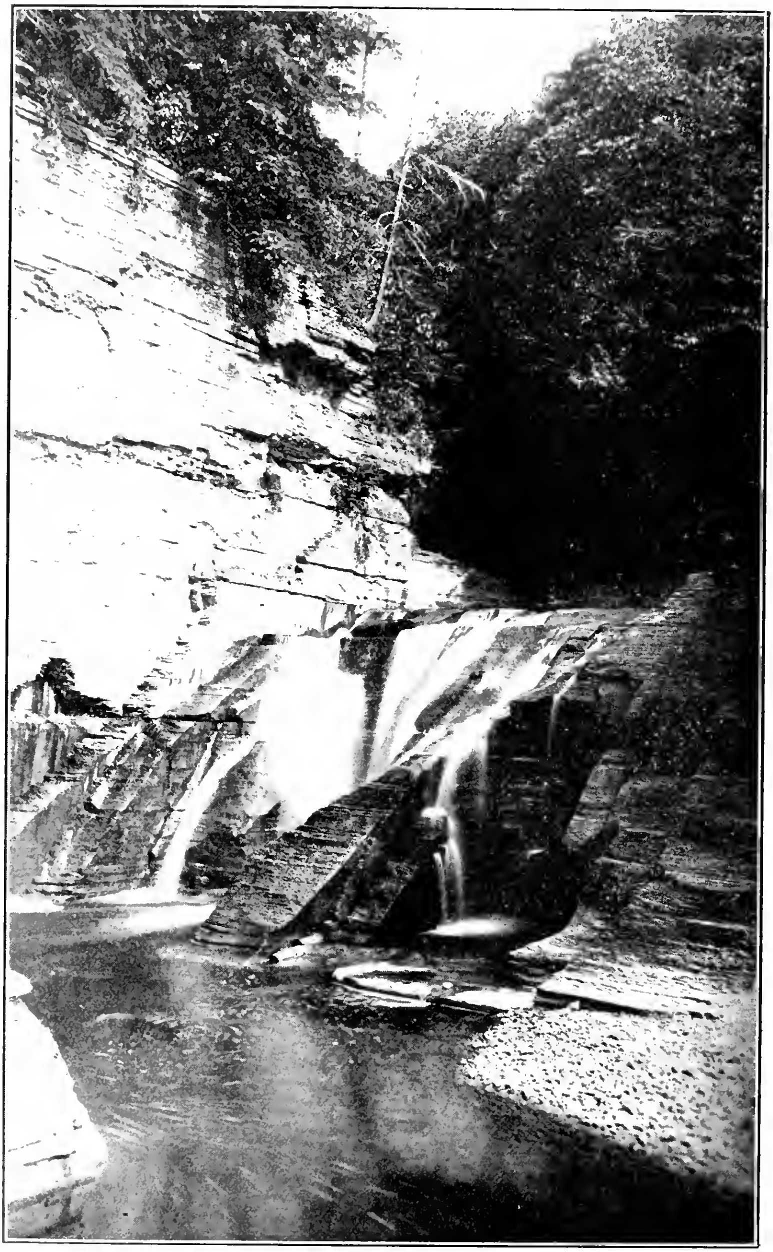


FIG. 8. GREENTREE FALLS IN SIX MILE CREEK, NEAR ITHACA, illustrating the influence of joint planes on gorge and waterfall form

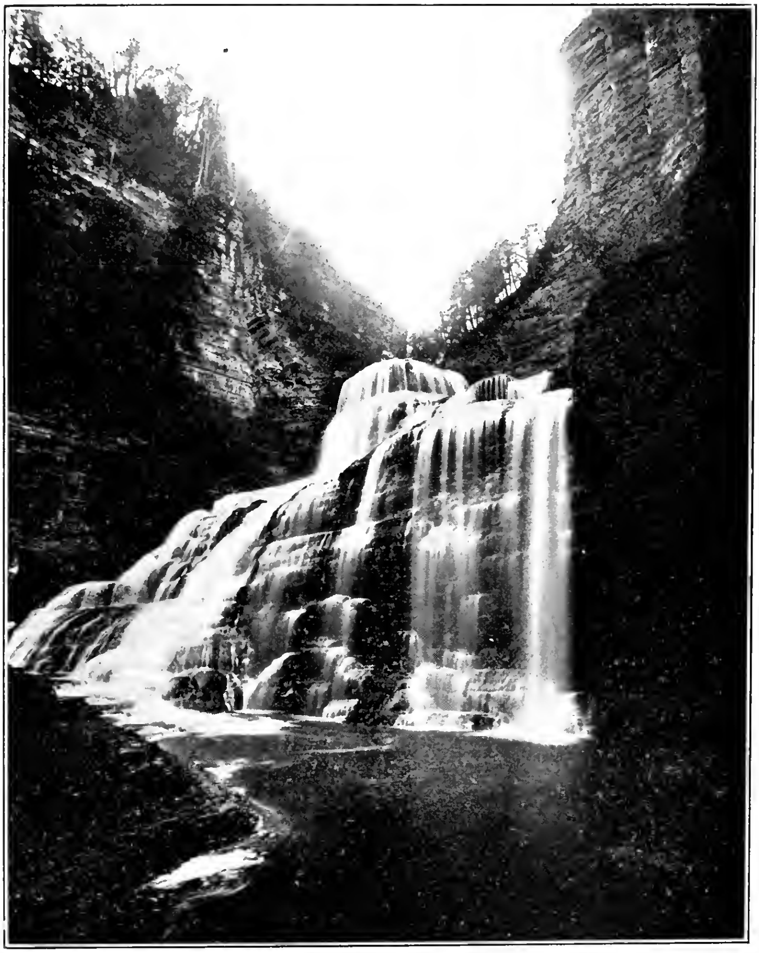


FIG. 9. STEP FALL IN ENFIELD (BUTTERNUT) CREEK, SOUTHWEST OF ITHACA, illustrating the influence of horizontal strata on waterfall form.

sandstone layers retard erosion and form falls, sometimes single leaps, sometimes step falls (Fig. 9) where the water cascades from ledge to ledge. With the variable spacing of the sandstone and shale layers, there is almost infinite variety in waterfall form.

The variation in gorge and waterfall form is still further increased by the joint planes which cleave the strata nearly vertically, and thus introduce a cause for vertical variation in erosion in addition to the horizontal. Some of the most beautiful of the cascades are those where the stream erosion has etched out combinations of horizontal and vertical irregularity in the rock bed over which the water falls (Fig. 8). The joint planes often guide the stream course between the falls also, sometimes confining it between narrow, canyon-

FIG. 10. POT-HOLES, WATKINS GLEN.

like walls with smooth, straight sides, sometimes leading the stream into sharply rectangular courses where the water departs from one set of joints to the other, which extends at right angles. Both the horizontal stratification and the vertical joint planes also affect the outline of the gorge walls, giving rise to some striking and picturesque effects.[8]

Still another feature prominently illustrated in these gorges is the pot-hole, formed where the cascading waters bore into the stream bed and, grinding pebbles about in the swirling waters, form large, deep pools (Fig. 10), adding interesting variety to the scenery of the gorges.

[8] For further description of these phenomena see Tarr, *Bull. Amer. Geog. Soc.*, Vol. XXXVII., 1905, pp. 193–212.

which at every turn have some new feature of interest or beauty. All these varied phenomena, but best of all the pot-holes, are illustrated with great clearness and variety in the wonderfully picturesque Watkins Glen.

From the standpoint of either the geographer, the geologist or the lover of scenery, a visit to any of these glens is well worth one's while; but no single one is so easily accessible, nor presents such a variety of phenomena, as Watkins Glen. Nearer centers of population it would be far more famous than now, and would be visited by scores of thousands. Waterfalls and gorges in Europe which can not be compared in beauty or interest with a score of glens in the Finger Lake region are far better known to the traveling American than Watkins Glen. It seems well, therefore, that it should be taken by the state, made better known, and opened freely to the public.

A LEAGUE OF PEACE[1]

BY ANDREW CARNEGIE, Esq., LL.D.

Principal and Students of St. Andrews: My first words must be words of thanks, very grateful thanks, to those who have so kindly re-elected me their rector without a contest. The honor is deeply appreciated, I assure you. There is one feature, at least, connected with your choice, upon which I may venture to congratulate you, and also the university—the continuance of the services of my able and zealous assessor, Dr. Ross of Dunfermline, which I learn are highly valued.

My young constitutents, you are busily preparing to play your parts in the drama of life, resolved, I trust, to oppose and attack what is evil, to defend and strengthen what is good, and, if possible, to leave your part of the world a little better than you found it. You are already pondering over the career you will pursue, what problems you will study, upon what, and how, your powers can be most profitably exerted; and apart from the choice of a career I trust you ask yourselves what are the evils of this life, in which all our duties lie, which you should most strenuously endeavor to eradicate or at least to lessen,—what causes you will espouse, giving preference to these beyond all other public questions, for the student of St. Andrews is expected to devote both time and labor to his duties as a citizen, whatever his professional career. You will find the world much better than your forefathers did. There is profound satisfaction in this, that all grows better; but there is still one evil in our day, so far exceeding any other in extent and effect, that I venture to bring it to your notice.

Polygamy and slavery have been abolished by civilized nations. Duelling no longer exists where English is spoken. The right of private war and of privateering have passed away. Many other beneficent abolitions have been made in various fields; but there still remains the foulest blot that has ever disgraced the earth, the killing of civilized men by men like wild beasts as a permissible mode of settling international disputes, although in Rousseau's words, 'War is the foulest fiend ever vomited forth from the mouth of Hell.' As such, it has received from the earliest times, in each successive age till now, the fiercest denunciations of the holiest, wisest and best of men.

[1] A rectorial address delivered to the students in the University of St. Andrews, October 17, 1905.

Homer, about eight hundred and fifty years before Christ, tells us it is by no means fit for a man stained with blood and gore to pray to the gods, and that "Religious, social and domestic ties alike he violates, who willingly would court the honors of internal strife." ('Iliad,' IX., 63.)

He makes Zeus, the cloud-gatherer, look sternly at Ares, the God of War, saying: "Nay, thou renegade, sit not by me and whine. Most hateful art thou to me of all the Gods that dwell in Olympus; thou ever lovest strife, and wars and battles." ('Iliad,' V., line 891.)

Euripides, 480–406 B. C., cries, "Hapless mortals, why do ye get your spears and deal out death to fellow-men? Stay! from such work forbear!" . . . "Oh fools all ye who try to win the meed of valor through war, seeking thus to still this mortal coil, for if bloody contests are to decide, strife will never cease!"

Thucydides, who wrote his great work sometime between 423 B. C. and 403 B. C., asserts that "Wars spring from unseen and generally insignificant causes, the first outbreak being often but an explosion of anger." And he gives us the needed lesson for our day which should be accepted as an axiom: "It is wicked to proceed against him as a wrong-doer who is ready to refer the question to arbitration." Aristides praised Pericles, because, to avoid war, 'he is willing to accept arbitration.'

Andocides, about 440–388 B. C., says: "This then is the distinction, Athenians, which I draw between the two: peace means security for the people, war inevitable downfall."

Isocrates, 436–338 B. C., teaches that "Peace should be made with all mankind. It should be our care not only to make peace, but to maintain it. But this will never be until we are persuaded that quiet is better than disturbance, justice than injustice, the care of our own than grasping at what belongs to others." ('Oration on Peace.')

The sacred books of the east make peace their chief concern. "Thus does he (Buddha) live as a binder together of those who are divided, an encourager of those who are friends, a peacemaker, a lover of peace, impassioned for peace, a speaker of words that make for peace." ('Buddhist Suttas,' 5th century B. C.) "Now, wherein is his conduct good? Herein, that putting away the murder of that which lives, he abstains from destroying life. The cudgel and the sword he lays aside, and, full of modesty and pity, he is compassionate and kind to all creatures that have life." ('Buddhist Suttas.')

"Truly is the king our sovereign Lord! He has regulated the position of the princes; he has called in shields and spears; he has returned to their cases bows and arrows." ('The Shik King,' Decade I., Ode 10.)

Many hundred years before Christ, the Zendavesta pronounces 'Opposition to peace is a sin.'

The Buddhist commandment, six hundred years before our era, is 'Love all mankind equally.'

'To those of a noble disposition, the whole world is but one family,' says the Hindu.

Coming to the Romans, Cicero (106–43 B. C.) says: "War should only be undertaken by a highly civilized state to preserve either its religion or its existence." "There are two ways of ending a dispute—discussion and force: the latter manner is simply that of the brute beasts; the former is proper to beings gifted with reason." He also reminds the senate, "For in this assembly, before the matter was decided, I said many things in favor of peace, and even while war was going on I retained the same opinions, even at the risk of my own life." No better proof of the true patriot and leader can be given than this—a lesson much needed in our day.

Sallust (86–34 B. C.) recounts, "But after the Senate learned of the war between them, three young men were chosen to go out to Africa to both Kings, and in the words of the Senate, and of the people, announce to them that it was their will and advice that they lay down their arms and 'settle their disputes by arbitration rather than by the sword; since to act thus would be to the honor both of the Romans and themselves.'" ('Jugurtha,' XXI., 4.)

Virgil (70–19 B. C.) laments that "The love of arms and the mad wickedness of war are raging. . . . As for me, just come from war and reeking with fresh slaughter, it would be criminal for me to touch the gods till I shall have washed the pollution in the running stream."

From Seneca (4 B. C.–65 A. D.) we have this outburst: "We punish murders and massacres among private persons: what do we respecting wars, and the glorious crime of murdering whole nations?" . . . "The love of a conquest is a murderess. Conquerors are scourges not less harmful to humanity than floods and earthquakes."

Tacitus shrewdly observes, "To be sure every wicked man has the greatest power in stirring up tumult and discord; peace and quiet need the qualities of good men." ('Historiæ, IV., 1.) This is why the demagogue comes to the surface, to inflame the passions of the multitude, that he may ride to power upon them. Beware of the man who leads you into war.

Josephus, born only thirty-eight years after Christ, writes: "David said, 'I was willing to build God a temple myself, but he prohibited me, because I was polluted with blood and wars.'"

Plutarch, born 46 A. D., holds that "There is no war among men not born of wickedness; some are aroused by desire of pleasures, others by too great eagerness for influence and power."

Such are a few examples from the testimony of the ancients.

I now solicit your attention to the views held and expressed by the early christian fathers, which can not but be of special importance to such of you as are theological students.

Justin Martyr, who died about 165 A. D., proclaims, "That the prophecy is fulfilled we have good reason to believe, for we (Christians), who in the past killed one another, do not now fight our enemies."

St. Irenæus, about 140–202 A. D., boasts that "The Christians have changed their swords and their lances into instruments of peace, and they know not how to fight."

Clement of Alexandria, whose works were composed in the end of the second century and beginning of the third, writes, 'The followers of Christ use none of the implements of war.'

Tertullian, about 150–230 A. D., asks, "How shall a Christian go to war, how shall he carry arms in time of peace, when the Lord has forbidden the sword to us? . . . Jesus Christ, in disarming St. Peter, disarmed all soldiers." ('De Idololatr.,' 19.) "The military oath and the baptismal vow are inconsistent with each other, the one being the sign of Christ, the other of the Devil." . . . "Shall it be held lawful to make an occupation of the sword, when the Lord proclaims that he who uses the sword shall perish by the sword?"

Origen, 185–254 A. D., says, "The angels wonder that peace is come through Jesus to earth, for it is a place ridden with wars." "This is called peace, where none is at variance, nothing is out of harmony, where there is nothing hostile, nothing barbarian." "For no longer do we (Christians) take arms against any race, or learn to wage war, inasmuch as we have been made sons of peace through Jesus, whom we follow as our leader." ('Patrologia Græca,' XIV., pp. 46, 988, 1231.)

St. Cyprian, about 200–257 A. D., boasts that "Christians do not in turn assail their assailants, since it is not lawful for the innocent even to kill the guilty; but they readily deliver up their lives and blood." (Epistle 56, to Cornelius, section 2.)

Arnobius, who wrote about 295 A. D., says. "Certainly, if all who look upon themselves as men would listen awhile unto Christ's wholesome and peaceable decrees, the whole world long ago, turning the use of iron to milder works, should have lived in most quiet tranquility, and have met together in a firm and indissoluble league of most safe concord." ('Adversus Gentes,' Lib. I., page 6.)

Lactantius, who wrote in the beginning of the fourth century, insists that "It can never be lawful for a righteous man to go to war, for his warfare is unrighteous itself." "It is not murder that God rebukes; the civil laws punish that. God's prohibition is intended for those acts which men considered lawful. Therefore it is not permitted for a Christian to bear arms; justice is his armor. The divine command admits no exceptions; man is sacred and it is always a crime to take his life." ('Div. Inst.,' VI., 20.) Thus does he declaim against men-slayers: "This, then, is your road to immortality. To destroy cities, devastate territories, exterminate or enslave free peoples! The more you have ruined, robbed, and murdered men, the more you think yourselves noble and illustrious." ('Div. Inst.,' I., 48.)

Athanasius, 296–373 A. D., states that when people "hear the teaching of Christ, straightway instead of fighting they turn to husbandry, and instead of arming their hands with weapons they raise them in prayer." ('Incarnation of the Word,' section 52.)

St. Gregory of Nyssa, 335–395 A. D., preaches that "He who promises you profit, if you abstain from the ills of war, bestows on you two gifts—one the remission from the train of evils attendant on the strife, the other the strife itself." ('Patrologia Græca,' XLIV., p. 1282.)

St. Augustine, 354–430 A. D., declares that 'Not to keep peace is to spurn Christ.' ('Migne's Patrologia Latina,' XXXIII., p. 186.) He holds that 'defensive wars are the only just and lawful ones; it is in these alone that the soldier may be allowed to kill, when he can not otherwise protect his city and his brethren.' (Letter 47.)

Isidore of Pelusium, 370–450 A. D., is no less outspoken: "I say, although the slaughter of enemies in war may seem legitimate, although the columns to the victors are erected, telling of their illustrious crimes, yet if account be taken of the undeniable and supreme brotherhood of man, not even these are free from evil." ('Patrologia Græca,' LXXVIII., p. 1287.)

We have also the undisputed historical record of Maximilian, the centurion, who, having embraced christianity, resigned his position and refused to fight. For this he was put to death.

Celsus, the great opponent of christianity, who wrote about 176 A. D., reproaches the christians for refusing to bear arms, and states that in one part of the Roman army, including one-third of the whole, 'Not a Christian could be found.'

Martin replied to Julian, the apostate, 'I am a Christian, and I can not fight.'

If we turn to the Popes, who were then supreme:

St. Gregory the Great, 540–604 A. D., writes the King of the Lombards, 'By choosing peace you have shown yourself a lover of God who is its author.'

Pope Innocent III., to the King of France, in protest against the wars between Philip Augustus and Richard of England, writes, "At the moment when Jesus Christ is about to complete the mystery of redemption, he gives peace as a heritage to his disciples; he wills that they observe it among themselves and make it observed by others. What he says at his death, he confirms after his resurrection. 'Peace be with you.' These are the first words which he addressed to his Apostles. Peace is the expression of that love which is the fulfilling of the law. What is more contrary to love than the quarrels of men? Born of hate, they destroy every bond of affection; and shall he who loves not his neighbour love God?"

Erasmus declares, "If there is in the affairs of mortal men any one thing which it is proper to explode, and incumbent upon every man by every lawful means to avoid, to deprecate, to oppose, that one thing is doubtless war."

Luther declares, "Cannons and firearms are cruel and damnable machines. I believe them to have been the direct suggestion of the Devil. If Adam had seen in vision the horrible instruments his children were to invent, he would have died of grief."

Nothing can be clearer than that the leaders of christianity immediately succeeding Christ, from whom authentic expressions of doctrines have come down to us, were well assured that their Master had forbidden to the christian the killing of men in war or enlisting in the legions. One of the chief differences which separated Roman non-christians and christians was the refusal of the latter to enlist in the legions and be thus bound to kill their fellows in war as directed. We may well ponder over the change, and wonder that christian priests accompany the armies of our day, and even dare to approach the Unknown, beseeching his protection and favor for soldiers in their heinous work. When the warring hosts are christian nations, worshipping the one God, which, alas, is not seldom, as in the last gigantic orgy of human slaughter in Europe, we had the spectacle of the rival priests, praying in the name of the Prince of Peace, to the God of Battles for favor. Similar prayers were offered in the churches, where in some instances battle-flags, the emblems of carnage, were displayed. Future ages are to pronounce all this blasphemous. There are those of to-day who deplore it deeply. Even the pagan, before Christ, direct from human butchery, refrained from appealing to his gods without first cleansing himself of the accruing pollution.

It is a truism that the doctrines of all founders of religions have undergone modifications in practise, but it is strange indeed that the doctrine of Christ regarding war and warriors, as held by his immediate followers, should have been so completely discarded and reversed in the later centuries, and is so still.

Bentham's words can not be overlooked: "Nothing can be worse than the general feeling on the subject of war. The church, the state, the ruling few, the subject man, all seem in this case to have combined to patronize vice and crime in their widest sphere of evil.

Dress a man in particular garments, call him by a particular name, and he shall have authority, on divers occasions, to commit every species of offense—to pillage, to murder, to destroy human felicity; and for so doing he shall be rewarded. The period will surely arrive when better instructed generations will require all the evidence of history to credit that, in times deeming themselves enlightened, human beings should have been honored with public approval in the very proportion of the misery they caused."

Bacon's words come to mind: "I am of opinion that, except you bray christianity in a mortar and mould it into new paste, there is no possibility of a holy war."

Apparently in no field of its work in our times does the christian church throughout the whole world, with outstanding individual exceptions of course, so conspicuously fail as in its attitude to war—judged by the standard maintained by the early christian fathers nearest in time to Christ. Its silence when outspoken speech might avert war, its silence during war's sway, its failure even during calm days of peace to proclaim the true christian doctrine regarding the killing of men made in God's image, and the prostitution of its holy offices to unholy warlike ends, give point to the recent arraignment of Prime Minister Balfour, who declared that the church to-day busies itself with questions which do not weigh even as dust in the balance compared with the vital problems with which it is called upon to deal.

Volumes could be filled with the denunciations of war by the great moderns. Only a few can be given.

Lord Clarendon, 1608–1674, says, "We can not make a more lively representation and emblem to ourselves of hell, than by the view of a kingdom in war."

Hume says, "The rage and violence of public war, what is it but a suspension of justice among the warring parties?"

Gibbon writes, "A single robber or a few associates are branded with their genuine name; but the exploits of a numerous band assume the character of lawful and honorable war."

'In every battlefield we see an inglorious arena of human degradation,' says Conway.

A strong voice from a St. Andrews principal is heard. Sir David Brewster, 1781–1868, says, "Nothing in the history of the species appears more inexplicable than that war, the child of barbarism, should exist in an age enlightened and civilized. But it is more inexplicable still that war should exist where christianity has for nearly 2,000 years been shedding its gentle light, and should be defended by arguments drawn from the Scriptures themselves."

One of the greatest American secretaries of state, Colonel John Hay, who has just passed away, denounced war as 'the most futile and ferocious of human follies.'

Much has man accomplished in his upward march from savagery. Much that was evil and disgraceful has been banished from life; but the indelible mark of war still remains to stain the earth and discredit our claim to civilization. After all our progress, human slaughter is still with us; but I ask your attention for a few minutes to many bright rays, piercing the dark cloud, which encourage us. Consider for a moment what war was in days past. It knew no laws, had no restrictions. Poison and assassination of opposing rulers and generals arranged by private bargain, and deceptive agreements, were legitimate weapons. Prisoners were massacred or enslaved. No quarter was given. Enemies were tortured and mutilated. Women, children and non-combatants were not spared. Wells were poisoned. Private property was not respected. Pillage was the rule. Privateering and private war were allowed. Neutral rights at sea were almost unknown.

Permit me briefly to trace the history of the reforms in war which have been achieved, from which we draw encouragement to labor for its abolition, strong in the faith that the days of man-slaying are numbered.

The first action against the savage custom of war is found in the rules of the Amphictyonic Council of the Greeks, some three hundred years before Christ. Hellenes were 'to quarrel as those who intend some day to be reconciled.' They were to "use friendly correction, and not to devastate Hellas or burn houses, or think that the whole population of a city, men, women and children, were equally their enemies and therefore to be destroyed."

We owe chiefly to Grotius the modern movement to subject hitherto lawless war on land and sea to the humane restraints of law. His first book, 'Mare Liberum,' appeared in 1609. It soon attracted such attention that Britain had to employ her greatest legal authority, Lord Selden, to make reply. Up to this time Spain, Portugal and Britain had maintained that the surrounding seas were closed to all countries except those upon their shores, a doctrine not formally abandoned by Britain until 1803.

Grotius's second and epoch-making work, 'The Rights of War and Peace,' appeared in 1625, and immediately arrested the attention of Gustavus Adolphus, the greatest warrior of his time. A copy was found in his tent when he died on the field of Lützen. He stood constantly for mercy, even in those barbarous days. Three years after its appearance, Cardinal Richelieu, to the amazement of Europe, spared the Huguenot garrison, and protected the city of Rochelle, when he was expected to follow the usual practise of massacring the defenders and giving the town and inhabitants over to massacre and pillage. It was then holy work to slay heretics, sparing not one. He was denounced for this merciful act by his own party and hailed as 'Cardinal of Satan' and 'Pope of the Atheists.' The Treaty of Westphalia in 1648, three years after the death of Grotius, closed the Thirty Years War in Germany, the Eighty Years' War in the Netherlands, and a long era of savagery in many parts of the globe. It shows clearly the influence of Grotius's advanced ideas, being founded upon his doctrine of the essential independence and equality of all sovereign states, and the laws of justice and mercy. In the progress of man from war, lawless and savage, to war restricted and obedient to international law, no name is entitled to rank with his. He is the father of modern international law, so far as it deals with the rights of peace and war. He has had several eminent successors, especially Puffendorf, Bynkershoek and Vattel. These four are called by Phillimore 'The Umpires of International Disputes.' They are followed closely by a second quartette, the British judge—Stowell, and the American judges—Marshall, Story and Field.

International law is unique in one respect. It has no material force behind it. It is a proof of the supreme force of gentleness—the irresistible pressure and final triumph of what is just and merciful. To the few who have contributed conspicuously to its growth in the past, and to those laboring therein to-day, civilization owes an unpayable debt. Private individuals have created it, and yet the nations have been glad to accept. British judges have repeatedly declared that 'International law is in full force in Britain.' It is so in America and other countries. We have in this self-created, self-developing and self-forcing agency one of the two most powerful and beneficent instruments for the peace and progress of the world.

The most important recent reforms effected in the laws of war are those of the Treaty of Paris (1856), the Treaty of Washington (1871), which settled the Alabama Claims, and the Brussels Declaration of 1874.

The Treaty of Paris marks an era as having enshrined certain principles. First, it abolished privateering. Henceforth, war on the sea is confined to national warships, organized and manned by officers and men in the service of the state. Commerce is no longer subject to attack by private adventurers seeking spoil. Second, it ruled that a blockade to be recognized must be effective. Third, it established the doctrine that an enemy's goods in a neutral ship are free, except contraband. These were great steps forward.

America declined to accept the first (in which, however, she has now concurred) unless private property was totally exempt on sea as on land, for which she has long contended, and which the powers, except Britain, have generally favored. So strongly has the current set recently in its favor that hopes are entertained that the forthcoming conference at The Hague may reach this desirable result. It is the final important advance in this direction that remains to be made, and means that peaceful commerce has been rescued from the demon war. Should it be made, the trenchers of St. Andrews students may well whirl in the air with cheers.

The Treaty of Washington is probably to rank in history as Mr. Gladstone's greatest service, because it settled by arbitration the Alabama Claims, a question fraught with danger, and which, if left open, would probably have driven apart and kept hostile to each other for a long period the two branches of the English-speaking race. A statesman less powerful with the great masses of his countrymen could not have carried the healing measure, for much had to be conceded by Britain, for which it deserves infinite credit. Three propositions were insisted upon by America as a basis for arbitration, and although all were reasonable and should have been part of international law, still they were not. Their fairness being recognized, Mr. Gladstone boldly and magnanimously agreed that the arbiters should be guided by them. These defined very clearly the duties of neutrals respecting the fitting out of ships of war in their ports, or the use of their ports as a naval base. This they must now use 'due diligence' to prevent.

Morley says, in his Life of Gladstone: "The Treaty of Washington and the Geneva arbitration stand out as the most noble victory in the 19th century of the noble art of preventive diplomacy, and the most signal exhibition in their history of self-command in two of three chief democratic powers of the Western World."

The Brussels Convention met in 1874.

Even as late as the earlier half of last century the giving up of towns and their inhabitants to the fury of the troops which stormed them was permitted by the usages of war. Defending his conduct in Spain, Wellington says: "I believe it has always been understood that the defenders of a fortress stormed have no right to quarter." After the storming of San Sebastian, as to plunder, he says: "It has fallen to my lot to take many towns by storm, and I am concerned to add that I never saw nor heard of one so taken by any troops that it was not plundered."

Shakespeare's description of the stormed city can never be forgotten:

> The gates of mercy shall be all shut up,
> And the flushed soldier rough and hard
> In liberty of bloody hand shall range
> With conscience wide as hell.

This inhuman practise was formally abolished by the Brussels Declaration—that 'a town taken by storm shall not be given up to the victorious troops to plunder.' To-day to put a garrison to the sword would be breach of the law of quarter, as well as a violation of the Brussels Declaration. We may rest assured the civilized world has seen the last of that atrocity.

We look back from the pinnacle of our high civilization with surprise and horror to find that even in Wellington's time, scarcely one hundred years ago, such savagery was the rule; but so shall our descendants after a like interval look back from a still higher pinnacle upon our slaying of man in war as equally atrocious, equally unnecessary and equally indefensible.

Let me summarize what has been gained so far in mitigating the atrocities of war in our march onward to the reign of peace. Non-combatants are now spared, women and children are no longer massacred, quarter is given, and prisoners are well cared for. Towns are not given over to pillage, private property on land is exempt, or if taken is paid or receipted for. Poisoned wells, assassination of rulers and commanders by private bargain, and deceptive agreements, are infamies of the past. On the sea, privateering has been abolished, neutral rights greatly extended and property protected, and the right of search narrowly restricted. So much is to be credited to the pacific power of international law. There is great cause for congratulation. If man has not been striking at the heart of the monster war, he has at least been busily engaged drawing some of its poisonous fangs.

Thus even throughout the savage reign of man-slaying we see the blessed law of evolution unceasingly at work performing its divine mission, making that which is better than what has been and ever leading us on towards perfection.

We have only touched the fringe of the crime so far, however, the essence of which is the slaughter of human beings, the failure to hold human life sacred, as the early christians did.

One deplorable exception exists to the march of improvement. A new stain has recently crept into the rules of war as foul as any that war has been forced by public sentiment to discard. It is the growth of recent years. Gentilis, Grotius and all the great publicists before Bynkershoek, dominated by the spirit of Roman law, by chivalry and long established practise, insist upon the necessity of a formal declaration of war, 'that he be not taken unawares under friendly guise.' Not until the beginning of the last century did the opposite view begin to find favor. To-day it is held that a formal declaration is not indispensable and that war may begin without it. Here is the only step backward to be met with in the steady progress of reforming the rules of war. It is no longer held to be contrary to these for a power to surprise and destroy while yet in friendly conference with its adversary, endeavoring to effect a peaceful settlement. It belongs to the infernal armory of assassins hired to kill or poison opposing generals, of forged despatches, poisoned wells, agreements made to be broken and all the diabolic weapons which, for very shame, men have been forced to abandon as too infamous even for the trade of man-slaying. It proclaims that any party to a dispute can first in his right hand carry gentle peace, sitting in friendly conference, ostensibly engaged in finding a peaceful solution of differences, while with the left he grasps, concealed, the assassin's dagger. The parallel between duel and war runs very close through history. The challenger to a duel gave the other party notice. In 1187, the German diet at Nuremberg enacted, "We decree and enact by this edict that he who intends to damage another or to injure him shall give him notice three days before." It is to be hoped that the coming conference will stamp this treachery as contrary to the rules of war, and thus return to the ancient and more chivalrous idea of attack only after notice.

We come now to the consideration of the other commanding force in the campaign against war—peaceful arbitration.

The originator of the world-wide arbitration idea was Emeric Cruce, born at Paris about 1590. Of his small book of 226 pages upon the subject only one copy exists. Gerloius had propounded the idea in the 12th century, but it failed to attract attention. Balch says, "Cruce presented what was probably the first real proposal of substituting international arbitration for war as the court of last resort of nations." It has a quaint preface: "This book would gladly make the tour of the inhabited world so as to be seen by all the kings, and it would not fear any disgrace, having truth for its escort and the merit of its subject, which must serve as letters of recommendation and credit."

Henry IV., in 1603, produced his scheme for consolidating Europe in order to abolish war; but as its fundamental idea was armed force and involved the overthrow of the Hapsburgs, it can not be considered as in line with the system of peaceful arbitration.

St. Pierre, the Duc de Lorraine, William Penn, the Quaker founder of Pennsylvania, Bentham, Kant, Mill and others have labored to substitute the reign of law for war by producing schemes much alike in character, so that we have many proofs of the irrepressible longing of man for release from the scourge.

I beg now to direct your attention to the most fruitful of all conferences that have ever taken place. Other conferences have been held, but always at the end of war, and their first duty was to restore peace between the belligerents. The Hague conference was the first ever called to discuss the means of establishing peace without reference to any particular war. Twenty-six nations were represented, including all the leading powers.

The conference was called by the present Emperor of Russia, August 24, 1898, and is destined to be forever memorable from having realized Cruce's ideal, and given to the world its first permanent court for the settlement of international disputes. The last century is in future ages to remain famous as having given birth to this high court of humanity. The conference opened upon the birthday of the Emperor, May 18th, 1899. The day may yet become one of the world's holidays in the coming day of peace, as that upon which humanity took one of its longest and highest steps in its history, onward and upward. As Ambassador White says, 'The Conference marks the first stage in the abolition of the scourge of war.' Such an achievement was scarcely expected, even by the most sanguine. Its accomplishment surprised most of the members of the conference themselves; but so deeply and generally had they been appalled by the ravages of war, and its enormous cost, by its inevitable progeny of future wars, and above all by its failure to ensure lasting peace, that the idea of a world court captivated the assembly, which has been pronounced the most distinguished that ever met. A less sweeping proposal would probably not have touched their imagination and aroused their enthusiasm. The prompt acceptance of the international court by public sentiment in all countries was no less surprising. Every one of the powers represented promptly ratified the treaty, the United States Senate voting unanimously—a rare event. We may justly accept this far-reaching and rapid success as evidence of a deep, general and earnest desire in all lands to depose war and enthrone peace through the judicial settlement of disputes by courts.

At last there is no excuse for war. A tribunal is now at hand to judge wisely and deliver righteous judgment between nations. It has made an auspicious start. A number of disputes have already been settled by it. First, it settled a difference between the United States and Mexico. Then President Roosevelt, when asked to act as arbiter, nobly led Britain, Germany, France, Italy, America and Venezuela to it for settlement of their differences, which has just been concluded.

Britain had recently a narrow escape from war with Russia, arising from the unfortunate incident upon the Dogger Bank, when fishing boats were struck by shots from Russian war-ships. There was intense excitement. The Hague Treaty provides that when such difficulties arise international commissions of inquiry be formed. This was the course pursued by two governments, parties to the treaty, which happily preserved the peace.

It was under another provision of the Hague conference that the President of the United States addressed his recent note to Japan and Russia suggesting a conference looking to peace, and offering his services to bring it about. His success was thus made possible by the Hague Treaty. The world is fast awakening to its far-reaching consequences and to the fact that the greatest advance man has ever made by one act is the creation of a world court to settle international disputes.

As I write, report comes that to-morrow the august tribunal is to begin hearing France and Britain upon their differences regarding Muscat. There sits the divinest conclave that ever graced the earth, judged by its mission, which is the fulfilment of the prophecy, "Men shall beat their swords into ploughshares, and their spears into pruning hooks; nation shall not lift up sword against nation, neither shall they learn war any more."

Thus the world court goes marching on, to the dethronement of savage war and the enthronement of peaceful arbitration.

The Hague tribunal has nothing compulsory about it; all members are left in perfect freedom as to whether they submit questions to it or not. This has sometimes been regarded as its weakness, but it is, from another point of view, its strongest feature. Like international law, it depends upon its merits to win its way, and, as we have seen, it is succeeding; but so anxious are many to hasten the abolition of war that suggestions are made towards obtaining the consent of the powers to agree to submit to it certain classes of questions. In this it may be well to make haste slowly and refrain from exerting pressure. This will all come in good time. Peace wins her way not by force; her appeal is to the reason and the conscience of man. In all treaties hitherto the great powers have retained power to withhold submission of questions affecting 'their honor or vital interests.' This was only natural at first, and time is required gradually to widen the range of subjects to be submitted. The tendency to do this is evident, and it only needs patience to reach the desired end. The greatest step forward in this direction is that Denmark and the Netherlands and Chili and Argentina have just concluded treaties agreeing to submit to arbitration all disputes, making no exception whatever. To crown this noble work, the latter two have erected a statue to the Prince of Peace on the highest peak of the Andes, which marks the long-disputed boundary between them.

Another splendid advance in this direction has been made in the agreement to arbitrate all questions between Sweden and Norway. Questions affecting 'independence, integrity or vital interests' are excepted; but should any difference arise as to what to do, that question is to be submitted. In other words, either nation can claim that a question does so, and, if the Hague tribunal agrees, it is not arbitrated. But if the tribunal decides the difference does not concern the 'independence, integrity or vital interests of either country,' then it is submitted to arbitration. This is certainly a step forward; and you will please note that intangible thing—'honor'—is omitted.

These nations are to be cordially congratulated on taking the initial step in this splendid advance. We grudge not the honor and glory that have fallen to them therefrom, though in our hearts we may feel that this might more appropriately have been the work of the race that abolished slavery, both branches participating, and also abolished the duel. What our race should now do is to follow the example set and conclude such a treaty, operative within the wide boundaries of English-speakers, empire and republic. Less than this were derogatory to our past as pioneers of progress. We can not long permit these small nations to march in advance. We should at least get abreast of them.

We have noted that honor or vital interests have hitherto been excepted from submission by arbitration treaties. We exclaim, 'Oh, Liberty, what crimes are committed in thy name!'—but these are trifling compared with those committed in the name of 'honor,' the most dishonored word in our language. Never did man or nation dishonor another man or nation. This is impossible. All honor's wounds are self-inflicted. All stains upon honor come from within, never from without. Innocence seeks no revenge; there is nothing to be revenged—guilt can never be. Man or nation whose honor needs vindication beyond a statement of the truth, which puts calumny to shame, is to be pitied. Innocence rests with that, truth has a quiet breast, for the guiltless find that

> So dear to heaven is saintly innocence,
> A thousand liveried angels lackey her
> To keep her from all sense of sin and shame.

Innocent honor, assailed, discards bloody revenge and seeks the halls of justice and of arbitration. It has been held in the past that, a man's honor assailed, vindication lay only through the sword. To-day it is sometimes still held that a nation's honor, assailed, can in like manner be vindicated only through war; but it is not open to a member of our race to hold this doctrine, for within its wide boundaries no dispute between men can be lawfully adjusted outside the courts of law. Instead of vindicating his honor, the English-speaking man who violated the law by seeking redress by personal violence would dishonor himself. Under our law, no wrong against man can be committed that justifies the crime of private vengeance after its commission.

The man of our race who holds that his country would be dishonored by agreeing to unrestricted arbitration forgets that according to this standard he is personally dishonored by doing that very thing. Individually he has become civilized, nationally he remains barbaric, refusing peaceful settlement and insisting upon national revenge—all for injured honor.

Which of us would not rejoice to have Britain and America share with Denmark and Holland, Chili and Argentina, the 'dishonor' they have recently incurred, and esteem it a proud possession?

Nations are only aggregates of the individual. The parallel between war and the duel is complete; and as society within our race already relies upon courts of justice to protect its members from all wrongs, so shall the nations finally rely upon international courts.

Objection has been made that unreasonable, dishonoring or baseless claims might be made under arbitration. That any member of the family of nations would present a claim wholly without basis, or that the court would not decide against it if made, is a danger purely hypothetical. The agreement between nations when made will undoubtedly be framed in accordance with the ideas of Grotius, and the independence and equality of all members and their existing territories recognized. These could not be assailed.

Three incidents have occurred since the court was organized which have caused much pain to the friends of peace throughout the world.

America refused the offer of the Filipinos to adjust their quarrel by arbitration. Britain refused the offer of the Transvaal Republic to arbitrate, although three of the court proposed by the republic were to be British judges, and the other two judges of Holland—the most remarkable offer ever made, highly creditable to the maker and a great tribute to British judges. Neither Russia nor Japan suggested submission to The Hague. Since the Hague Court is the result of the Russian Emperor's initiative, this caused equal surprise and pain. The explanation has been suggested that peaceful conferences were being held when Japan attacked at Port Arthur without notice, rendering arbitration impossible.

We must recognize these discouraging incidents, but we have the consolation left us of believing that, had either of the three nations seen, at the beginning, the consequences of ignoring arbitration, as clearly as they did later, they would have accepted arbitration and had reason to congratulate themselves upon the award of the court, whatever it was. They will learn by experience. Notwithstanding these regrettable failures to refer disputes to the Hague Court as peaceful umpire, we have abundant reason for satisfaction in the number of instances in which the court's award has already brought peace without the sacrifice of one human life—the victories which bring no tears.

Signs of action in favor of universal peace abound. Among these may be mentioned that the Inter-Parliamentary Union assembled at St. Louis last year requested the governments of the world to send representatives to an international conference to consider:—*First,* the questions for the consideration of which the conference at the Hague expressed a wish that a future conference be called. *Second,* the negotiation of arbitration treaties between the nations represented. *Third,* the advisability of establishing an international congress to be convened periodically for the discussion of international questions.

President Roosevelt invited the nations to call the conference, but has recently deferred to the Emperor of Russia as the proper party to call the nations together again.

Should the proposed periodic congress be established, we shall have the germ of the council of nations, which is coming to keep the peace of the world, judging between nations, as the Supreme Court of the United States judges to-day between states embracing an area larger than Europe. It will be no novelty, but merely an extension of an agency already proved upon a smaller scale. As we dwell upon the rapid strides towards peace which man is making, the thought arises that there may be those now present, who will live to see this world council established, through which is sure to come in the course of time the banishment of man-slaying among civilized nations.

I hope my hearers will follow closely the proceedings of the Hague conference, for upon its ever-extending sway largely depends the coming of the reign of peace. Its next meeting will be important, perhaps epoch-making. Its creation and speedy success prepare us for surprisingly rapid progress. Even the smallest further step taken in any peaceful direction would soon lead to successive steps thereafter. The tide has set in at last, and is flowing as never before for the principle of arbitration as against war.

So much for the temple of peace at The Hague. Permit me a few words upon arbitration in general.

The statesmen who first foresaw and proved the benefits of modern arbitration were Washington, Franklin, Hamilton, Jay and Grenville.

As early as 1780 Franklin writes, "We make daily great improvements in Natural, there is one I wish to see in Moral, Philosophy—the discovery of a plan that would induce and oblige nations to settle their disputes without first cutting each other's throats." His wish was realized in the Jay Treaty of 1794, from which modern arbitration dates. It is noteworthy that this treaty was the child of our race and that the most important questions which arbitration has settled so far have been those between its two branches.

It may surprise you to learn that from the date of the Jay Treaty, one hundred and eleven years ago, no less than five hundred and seventy-one international disputes have been settled by arbitration. Not in any case has an award been questioned or disregarded, except, I believe, in one case, where the arbiters misunderstood their powers. If in every ten of these differences so quietly adjusted without a wound, there lurked one war, it follows that peaceful settlement has prevented fifty-seven wars—one every two years. More than this, had the fifty-seven wars, assumed as prevented by arbitration, developed, they would have sown the seeds of many future wars, for there is no such prolific mother of wars as war itself. Hate breeds hate, quarrel breeds quarrels, war breeds war—a hateful progeny. It is the poorest of all remedies. It poisons as it cures. No truer line was ever penned than this of Milton's, 'For what can war but endless war still breed?'

No less than twenty-three international treaties of arbitration have been made within the past two years. The United States made ten with the principal powers, which only failed to be formally executed because the senate, which shares with our executive the treaty-making power to the extent that its approval is necessary, thought it advisable to change one word only—'treaty' for 'agreement'—which proved unsatisfactory to the executive. The vote of the senate was almost unanimous, showing an overwhelming sentiment for arbitration. The internal difference will no doubt be adjusted.

You will judge from these facts how rapidly arbitration is spreading. Once tried, there is no backward step. It produces peace and leaves no bitterness. The parties to it become better friends than before; war makes them enemies.

Much has been written upon the fearful cost of war in our day, the ever-increasing blood tax of nations, which threatens soon to approach the point of exhaustion in several European lands. To-day France leads with an expenditure of £3 14s and a debt of £31 3s 8d per head. Britain follows with an annual expenditure of £3 8s 8d and a debt of £18 10s 5d per head. Germany's expenditure is in great contrast—only £1 15s 4d, not much more than one-third; her debt, £2 12s 2d, not one-sixth that of Britain. Russia's expenditure is £1 14s 6d, about the same as the German; her debt £5 9s 9d per head.

The military and naval expenditure of Britain is fully half of her total expenditure; that of the other great powers, though less, is rapidly increasing.

All the great national debts, with trifling exceptions—Britain's eight hundred millions, France's twelve hundred millions sterling—are the legacies of war.

This drain, with the economic loss of life added, is forcing itself upon the nations concerned as never before. It threatens soon to become dangerous unless the rapid increase of recent years be stopped; but it is to be feared that not till after the financial catastrophe occurs will nations devote themselves seriously to apply the cure.

The futility of war as a means of producing peace between nations has often been dwelt upon. It is really the most futile of all remedies, because it embitters contestants and sows the seeds of future struggles. Generations are sometimes required to eradicate the hostility engendered by one conflict. War sows dragons' teeth, and seldom gives to either party what it fought for. When it does, the spoil generally proves Dead Sea fruit. The terrible war just concluded is another case in point. Neither contestant obtained what he fought for, the reputed victor being most of all disappointed at last with the terms of peace. Had Japan, a very poor country, known that the result would be a debt of two hundred millions sterling loading her down, or had Russia known the result, differences would have been peacefully arbitrated. Such considerations find no place, however, in the fiery furnace of popular clamor; as little do those of cost or loss of life. Only if the moral wrong, the sin in itself, of man-slaying is brought home to the conscience of the masses may we hope speedily to banish war. There will, we fear, always be demagogues in our day to inflame their brutal passions and urge men to fight, as a point of honor and patriotism, scouting arbitration as a cowardly refuge. All thoughts of cost or loss of human life vanish when the brute in man, thus aroused, gains sway.

It is the crime of destroying human life by war and the duty to offer or accept peaceful arbitration as a substitute which need to be established, and which, as we think, those of the church, the universities, and of the professions are called upon to strongly emphasize.

If the principal European nations were not free through conscription from the problem which now disturbs the military authorities of Britain, the lack of sufficient numbers willing to enter the man-slaying profession, we should soon hear the demand formulated for a league of peace among the nations. The subject of war can never be studied without recalling this simplest of all modes for its abolition. Five nations cooperated in quelling the recent Chinese disorders and rescuing their representatives in Pekin. It is perfectly clear that these five nations could banish war. Suppose even three of them formed a league of peace—inviting all other nations to join—and agreed that since war in any part of the civilized world affects all nations, and often seriously, no nation shall go to war, but shall refer international disputes to the Hague conference or other arbitral body for peaceful settlement, the league agreeing to declare non-intercourse with any nation refusing compliance. Imagine a nation cut off to-day from the world. The league also might reserve to itself the right, where non-intercourse is likely to fail or has failed to prevent war, to use the necessary force to maintain peace, each member of the league agreeing to provide the needed forces, or money in lieu thereof, in proportion to her population or wealth. Being experimental and upon trial, it might be deemed advisable, if necessary, at first to agree that any member could withdraw after giving five years' notice, and that the league should dissolve five years after a majority vote of all the members. Further provisions, and perhaps some adaptations, would be found requisite, but the main idea is here.

The Emperor of Russia called the Hague conference, which gave us an international tribunal. Were King Edward or the Emperor of

Germany or the President of France, acting for their governments, to invite the nations to send representatives to consider the wisdom of forming such a league, the invitation would no doubt be responded to and probably prove successful.

The number that would gladly join such a league would be great, for the smaller nations would welcome the opportunity.

The relations between Britain, France and the United States to-day are so close, their aims so similar, their territories and fields of operation so clearly defined and so different, that these powers might properly unite in inviting other nations to consider the question of such a league as has been sketched. It is a subject well worthy the attention of their rulers, for of all the modes of hastening the end of war this appears the easiest and the best. We have no reason to doubt that arbitration in its present optional form will continue its rapid progress, and that it in itself contains the elements required finally to lead us to peace, for it conquers wherever it is tried; but it is none the less gratifying to know that there is in reserve a drastic mode of enforcement, if needed, which would promptly banish war.

Notwithstanding all the cheering signs of the growth of arbitration, we should delude ourselves if we assumed that war is immediately to cease, for it is scarcely to be hoped that the future has not to witness more than one great holocaust of men to be offered up before the reign of peace blesses the earth. The scoria from the smoldering mass of the fiery past, the seeds that great wars have sown, may be expected to burst out at intervals more and more remote, until the poison of the past is exhausted. That there is to be perfect unbroken peace in our progress to this end we are not so unduly sanguine as to imagine. We are prepared for more than one outbreak of madness and folly in the future as in the past; but that peace is to come at last, and that sooner, much sooner, than the majority of my hearers can probably credit, I for one entertain not one particle of doubt.

We sometimes hear, in defense of war, that it develops the manly virtue of courage. This means only physical courage, which some animals and the lower order of savage men possess in the highest degree. According to this idea, the more man resembles the bulldog the higher he is developed as man. The Zulus, armed with spears, rush upon repeating rifles, not because unduly endowed with true courage, but because they lack common sense. One session or less at St. Andrews University would cure them of their folly. In our scientific day, beyond any that has preceded, discretion is by far the better part of valor. Officers and men, brave to a fault, expose themselves needlessly and die for the country they would have better served by sheltering themselves and living for. Physical courage is far too common to be specially extolled. Japanese, Russian and Turk, Zulu and Achenese are all famous for it. It is often allied with moral cowardice. Hotspur is an ideal physical-courage hero when he exclaims—

> By heaven, methinks it were an easy leap,
> To pluck bright honor from the pale-faced moon,
> Or dive into the bottom of the deep,
> Where fathom-line could never touch the ground,
> And pluck up drowned honor by the locks;
> So that he that doth redeem her thence might wear
> Without corrival all her dignities.

Vain peacock, unless he could reap the glory and strut bespangled with glittering decorations, he cared not to achieve. All for himself, nothing for the cause, nothing for his country.

Achilles, sulking in his tent, incensed upon the question of loot and praying the gods to defeat his own countrymen, is another example of a physically courageous military hero. Fortunately our modern military men are generally of a different type. It is not the individual who conforms to the standard of his age, but the bad standard of the age that is to be condemned. Men are to be judged only by the standard of their time, and though our standard of to-day may be low indeed, the men conforming to it are not to be decried.

If you would be lifted up and inspired by worshipping at the shrine of the much nobler and rarer virtue, moral courage, stand before the Martyrs' Monument yonder. The martyrs cared nothing for earthly glory and honor or reward; their duty was to stand for a noble cause, and for that, not for their own selfish exaltation, they marched through fire and fagot to death unflinchingly, chanting as they marched.

There is one very encouraging indication of progress within our race, as showing, it is to be hoped, the influence of education upon the masses in evolving clearer ideas of responsibility for their actions. The attention of parliament was recently called to the difficulty of obtaining recruits for the army. The shortage of officers in the auxiliary forces (volunteers and militia) is no less than twenty-five per cent.—one-fourth of the whole. The militia has 32,000 men less than before. The regular army lacks 242 officers, and the British army for India is short 12,000 British recruits. The government pronounces this 'the most serious problem which confronts the military authorities.' Some of the highest military authorities see the final remedy only in conscription. I rejoice to inform you that your kin beyond sea in America have on hand the very same problem for their navy. Their army, being so small, is not yet affected. All their war-ships can not be manned—3,500 men are lacking. From this shortage of recruits we are justified in concluding that there is no longer a general desire in our race to enter the services. This is specially significant, as we are informed that increase of pay would not greatly increase recruiting, as recruits are obtained chiefly from a certain class. We hear of a like trouble in another profession, a scarcity of young, educated, conscientious men desirous of entering the ministry, thought to be owing to the theological tenets to which they are required to subscribe. Both branches of the church in Scotland have accordingly endeavored to meet this problem by substituting less objectionable terms.

Perhaps from the public library young men have taken Carlyle and read how he describes the artisans of Britain and France: "Thirty stand fronting thirty, each with a gun in his hand. Straightway the word 'fire' is given, and they blow the souls out of one another; and in place of sixty brisk, useful craftsmen, the world has sixty dead carcases, which it must bury and anew shed tears for. Had these men any quarrel? Busy as the devil is, not the smallest! They lived far enough apart, were the entirest strangers; nay in so wide a universe there was even, unconsciously, by commerce, some mutual helpfulness between them. How then? Simpleton! Their governors had fallen out, and, instead of shooting one another, had the cunning to make these poor blockheads shoot."

Those who decline the advances of the decorated recruiting officer may have stumbled upon Professor MacMichael's address to the Peace Congress at Edinburgh, 1853, when he said: "The military profession is inconsistent with Christianity. The higher the rank and the greater the intellect, the more desperate the criminality. Here is a person upon whom God has conferred the rare gift of mathematical genius. If properly directed, what an abundant source of benefit to mankind! It might be employed in the construction of railways, by which the most distant parts of the world are brought into communication with each other. It might be employed in flashing the trembling lightning across the wires, making them the medium of intercourse between loving hearts thousands of miles apart; in increasing the wonderful powers of the steam-engine, relieving man from his exhausting toils; in application to the printing-press, sending light and knowledge to the farthest extremities of the earth. It might be employed in draining marshes, in supplying our towns and cities with water, and in adding to the health and happiness of men. It might lay down rules derived from the starry heavens, by which the mariner is guided through the wild wastes of waters in the darkest night. How noble is science when thus directed, but in the same proportion how debasing does it become when directed to human destruction! It is as if a chemist were to make use of his knowledge not to cure the diseases of which humanity is suffering, but to poison the springs of existence. The scientific soldier cultivates his endowments for what purpose? That he may determine the precise direction at which these batteries may vomit forth their fire so as to destroy most property and most lives; that he may calculate the precise angles and force with which these shells may be sent up into the air that they may fall upon that particular spot which is thronged with men, and, exploding there, send havoc among them. Great God! am I at liberty to devote my faculties to the infernal work?"

That is a voice from Dunfermline of weighty import. I found it recently and rejoiced that, when a child, I had often seen the man who wrote these words.

Wyclif's opinion may have arrested the young men's attention: "What honor falls to a knight that kills many men? The hangman killeth many more and with a better title. Better were it for men to be butchers of beasts than butchers of their brethren!"

Or John Wesley's wail may have struck deep in the hearts of some fit for recruits: "You may pour out your soul and bemoan the loss of true, genuine love in the earth. Lost indeed! These *Christian* kingdoms that are tearing out each other's bowels, desolating one another with fire and sword! These Christian armies that are sending each other by thousands, by tens of thousands, quick to hell!"

It may be from eminent soldiers that young men have received the most discouraging accounts of the profession. Napoleon declared it 'the trade of barbarians.' Wellington writes Lord Shaftesbury, "War is a most detestable thing. If you had seen but one day of war, you would pray God you might never see another." General Grant, offered a military review by the Duke of Cambridge, declined, saying he never wished to look upon a regiment of soldiers again. General Sherman writes he was "tired and sick of the war. Its glory is all moonshine. It is only those who have neither fired a shot nor heard the shrieks and groans of the wounded, who cry aloud for more blood, more vengeance, more desolation. War is Hell."

Perhaps some have pondered over Sir John Sinclair's opinion that 'the profession of a soldier is a damnable profession.'

The professional soldier is primarily required for purposes of aggression, it being clear that if there were none to attack, none to defend would be needed. The volunteer, who arms only to be better able to defend his home and country, occupies a very different position from the recruit who enlists unconditionally as a profession and binds himself to go forth and slay his fellows as directed. The defense of home and country may possibly become necessary, although no man living in Britain or America has ever seen invasion or is at all likely to see it. Still, the elements of patriotism and duty enter here. That it is every man's duty to defend home and country goes without saying. *We should never forget, however, that which makes it a holy duty to defend one's home and country also makes it a holy duty not to invade the country and home of others,* a truth which has not hitherto been kept in mind. The more's the pity, for in our time it is one incumbent upon the thoughtful peace-loving man to remember. The professional career is an affair of hire and salary. No duty calls any man to adopt the naval or military profession and engage to go forth to kill other men when and where ordered, without reference to the right or wrong of the quarrel. It is a serious engagement involving as we lookers-on see it, a complete surrender of the power most precious to man—the right of private judgment and appeal to conscience. Jay, the father of the first treaty between Britain and America, has not failed to point out that "our country, right or wrong, is rebellion against God and treason to the cause of civil and religious liberty, of justice and humanity."

Just in proportion as man becomes truly intelligent, we must expect him to realize more and more that he himself alone is responsible for his selection of an occupation, and that neither pope, priest nor king can relieve him from this responsibility.

It was all very well for the untaught, illiterate hind, pressed into King Henry's service, to argue, "Now, if these men do not die well, it will be a black matter for the King that led them to it, whom to disobey were against all proportion of subjection." The schoolmaster has been abroad since then. The divine right of kings has gone. The mass of English-speaking men now make and unmake their kings, scout infallibility of power of pope or priest, and in extreme cases sometimes venture to argue a point even with their own minister. The 'Judge within' begins to rule. Whether a young man decides to devote his powers to making of himself an efficient instrument for injuring or destroying, or for saving and serving his fellows, rests with himself to decide after serious consideration.

To meet the scarcity of officers, the government stated that it was considering the policy of looking to the universities for the needed supply, and that steps might be taken to encourage the study of war with a view to enlistment; but if university students are so far advanced ethically as to decline pledging themselves to preach 'creeds outworn'—rightfully most careful to heed the 'Judge within,' their own conscience—universities will probably be found poor recruiting ground for men required to pledge themselves to go forth and slay their fellow men at another's bidding. The day of humiliation will have come upon universities when their graduates, upon whom have been spent years of careful education in all that is highest and best, find themselves at the end good for nothing better than 'food for powder.' I think I hear the response of the son of St. Andrews to the recruiting officer, 'Is thy servant a dog that he should do this thing?'

From one point of view, the scarcity of officers and recruits in Britain and America, where men are free to choose, and the refusal of university students to compromise themselves by pledges upon entering the ministry, are most cheering, evincing as they do a keener sense of personal responsibility, a stronger appeal to conscience—the 'Judge within'—more tender and sympathetic natures, a higher standard of human action and altogether a higher type of man.

If war requires a surrender of all these by its recruits, much better we should face the alternative and let Britain and America depend upon the patriotism of citizens to defend their countries if attacked, in which duty I for one strongly believe they will never be found inefficient. Colonel Henderson, in his 'Science of War,' states "that the American Volunteers were superior to the conscript levies of Europe—that the morale of conscript armies has always been their weakest point. The morale of the volunteer is of a higher type." This stands to reason.

Should Britain ever be invaded, the whole male population able to march would volunteer, and from many parts of the world thousands would rush to the defense of the old home. Those who invade the land of Shakespeare and Burns will find they have to face forces they never reckoned upon. The hearts and consciences of all would be in the work; and 'Thrice is he armed who hath his quarrel just.'

Students of St. Andrews, my effort has been to give you a correct idea of the movement now stirring the world for the abolition of war, and what it has already accomplished. It never was so widespread or so vigorous, nor at any stage of the campaign have its triumphs been so numerous and important as those of the last few years, beginning with the Hague conference, which in itself marks an epoch. The foundation stone of the structure to come was then laid. The absolute surrender by four nations of all future differences to arbitration, and Norway and Sweden's agreement, mark another stage. Thus the civilized world at last moves steadily to the reign of peace through arbitration.

The question has no doubt arisen in your minds, what is your duty and how can you best cooperate in this holy work and hasten the end of war. I advise you to adopt Washington's words as your own, 'My first wish is to see this plague of mankind, war, banished from the earth.' Leagues of peace might be formed over the world with these words as their motto and basis of action. How are we to realize this pious wish of Washington's? may be asked. Here is the answer. Whenever an international dispute arises, no matter what party is in power, demand at once that your government offer to refer it to arbitration, and if necessary break with your party. Peace is above party. Should the adversary have forestalled your government in offering arbitration, which for the sake of our race I trust will never occur, then insist upon its acceptance and listen to nothing until it is accepted.

Drop all other public questions, concentrate your efforts upon the one question which carries in its bosom the issue of peace or of war. Lay aside your politics until this war issue is settled. This is the time to be effective. And what should the ministers of the churches be doing? Very different from what they have done in the past. They should cease to take shelter from the storm, hiding themselves in the recital of the usual formulas pertaining to a future life in which men in this life have no duties, when the nation is stirred upon one supreme moral issue, and its government, asserting the right to sit in judgment upon its own cause, is on the brink of committing the nation to unholy war—for unholy it must be if peaceful settlement offered by an adversary be refused. Refusal to arbitrate makes war, even for a good cause, unholy; an offer to arbitrate lends dignity and importance to a poor one. Should all efforts fail, and your country, rejecting the appeal to judicial arbitration, plunge into war, your duty does not end. Calmly resolute in adherence to your convictions, stating them when called upon, though never violently intruding them, you await the result, which can not fail to prove that those who stood for peaceful arbitration chose the right path and have been wise counsellors of their country. It is a melancholy fact that nations looking back have usually to confess that their wars have been blunders, which means they have been crimes.

And the women of the land, and the women students of St. Andrews—what shall they do? Not wait as usual until war has begun, and then, their sympathies aroused, organize innumerable societies for making and sending necessaries and even luxuries to the front, or join Red Cross societies and go themselves to the field, nursing the wounded that these may the sooner be able to return to the ranks to wound others or be again wounded, or to kill or be killed. The tender chords of sympathy for the injured, which grace women, and are so easily stirred, are always to be cherished; but it may be suggested that were their united voices raised in stern opposition to war before it was declared, urging the offer of arbitration, or in earnest remonstrance against refusing it, one day of effort would then prove more effective than months of it after war has begun.

It is certain that if the good people of all parties and creeds, sinking for the time other political questions whenever the issue of war arises, were to demand arbitration, no government dare refuse. They have it in their power in every emergency to save their country from war and ensure unbroken peace.

If in every constituency there were organized an arbitration league, consisting of members who agree that arbitration of international disputes must be offered, or accepted by the government if offered by the adversary, pledging themselves to vote in support of, or in opposition to, political parties according to their action upon this question, it would be surprising how soon both parties would accept arbitration as a policy. I know of no work that would prove more fruitful for your country and for the world than this. It is by concentrating upon one issue that great causes are won.

In this holy work of insisting upon arbitration, surely we may expect the men and women of St. Andrews, of all universities and other educational institutions, of all the churches and of all the professions to unite and take a prominent part. I quoted the words of Washington at the beginning of this appeal. Let me close by quoting the words of Lincoln. When a young man, employed upon a trading boat, he made a voyage of some weeks' duration upon the Mississippi. He visited a slave market, where men, women and children were not slaughtered, as formerly in war, but were separated and sold from the auction block. His companion tells that after standing for some time Lincoln turned and walked silently away. Lifting his clenched hand, his first words were, 'If ever I get a chance, I shall hit this accursed thing hard.' Many years passed, during which he never failed to stand forth as the bitter foe of slavery and the champion of the slave. This was for him the paramount issue. He was true to his resolve throughout life, and in the course of events his time came at last. This poor, young, toiling boatman became president of the United States, and was privileged with a stroke of his pen to emancipate the slaves last remaining in the civilized world, four millions in number. He kept the faith, and gave the lesson for all of us in our day, who have still with us war in all its enormity, many of us more or less responsible for it, because we have not hitherto placed it above all other evils and concentrated our efforts sufficiently upon its extinction. Let us resolve like Lincoln, and select man-slaying as our foe, as he did man-selling. Let us, as he did, subordinate all other public questions to the one over-shadowing question, and, as he did, stand forth upon all suitable occasions to champion the cause. Let us, like him, keep the faith, and as his time came, so to us our time will come, and, as it does, let us hit accursed war hard until we drive it from the civilized world, as he did slavery.

THE BODY'S UTILIZATION OF FAT

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RECENT physiology has considerably advanced our knowledge of fatty metabolism. Some of the recent work has had an important bearing on metabolism in general, as well as on the special metabolism of fats. This article aims to outline the results of some of the more important experimental work on the subject.

Fat is the form in which the body lays up its greatest supply of potential energy. Plants also store energy, but they do it chiefly in the form of sugar and starch or, to give these substances a single name, *carbohydrate.* As the animal kingdom is parasitic directly or indirectly upon the vegetable, it results that the animal's food is largely composed of carbohydrate. Thus Voit's figures, expressing the needs of an adult man, are 118 grams of proteid,[1] 50 grams of fat and 500 grams of carbohydrate food in twenty-four hours.

But there are good reasons why carbohydrate, which is our most abundant and cheapest food, would not be an economical store of energy for the animal body. Chief among these is the fact that animals are for the most part motile and hence the advantage of having their store of energy-producing compounds in small compass and of light weight. Fat fulfils the indications admirably, since its atoms, carbon and hydrogen, are light, since a given weight is capable of combining with a large amount of oxygen and since it can be completely oxidized in the body, *i. e.,* the body is able to utilize all its potential energy.

Not all our fat comes from the fat of our food, but is made in the body from other substances. There are two theories—one that it is made from carbohydrate, the other that it is made from proteid.

An animal can be fattened without giving it any fat in its food, in fact, the usual method of fattening animals is by increasing their carbohydrate food. Though there is some question of the origin of fat from proteid, there can be little or none as to the transformation of carbohydrate into fat. This knowledge that fat can be so made upsets one of the notions largely held till recently as to the kind of chemistry

[1] Chittenden has investigated our proteid needs very carefully and would probably agree that these figures fairly well represent what the average man does consume, but he finds that such a quantity of proteid is much beyond actual needs. He found men able to do work of all kinds, both mental and physical, and retain good health on one third to one half this quantity of proteid.

of which the animal as distinguished from the vegetable body is capable. It was thought that animal chemistry was all of a sort which would produce more fixed and stable compounds and convert compounds of greater potential energy into those of little or none. On the other hand, the synthesis of organic compounds was believed to be confined to the vegetable kingdom. This distinction in the character of the chemical processes in the two forms of living things was believed to be one of their fundamental differences. It is still true that the end products of animal metabolism are simple oxidized substances and that plants are largely engaged in synthetic chemistry, but the difference in this regard is one of degree only. The number of known synthetic processes occurring in the animal body is constantly increasing, and the formation of the complex fat molecule from the comparatively simple and partly-oxidized sugar molecule is an instance of a complex synthesis. To build up this fat molecule a number of sugar molecules must be disintegrated and a portion of each must be taken to be combined with others into the large molecule of neutral fat. Another, but more simple, synthesis, to be referred to later, is the synthesis of the neutral fat molecule from the fatty acid absorbed from the small intestine. In this process three molecules of fatty acid are used to make one molecule of neutral fat.

Our text-books only a few years old tell how fats are absorbed from the intestine by a process entirely different from that by which the sugars and proteids are absorbed.

The latter substances by an hydrolysis and cleavage are made soluble and diffusible and in this dissolved form are absorbed. We were told a different story of the fats—that while a portion of the fat was really digested, *i. e.*, converted into a fatty acid and glycerine and thus absorbed—that the greater part was simply emulsified and that the finely divided particles of fat were then 'swallowed whole' by the intestinal epithelium in some such way, to look for an illustration, as the amoeba takes its food. The evidence for this seemed fairly convincing; in the first place, the fat could be seen in the emulsified state in the intestine in contact with the epithelial cells lining it. And in the substance of these epithelial cells, as though just devoured from the intestinal contents, were seen similar droplets of fat. This view, however, has given place to the view that all the absorbed fat is first converted into fatty acid and absorbed in this form or perhaps partly also as a soap, then reconverted into neutral fat. The older theory was abandoned for the following reasons: No one saw the fat droplets passing into the cell; none were seen in the border of the cell in contact with the intestinal contents, but only at the base of the cell farthest removed from the source of supply of fat. The same appearances in the epithelial cells were noted if a dog was fed with no fat, but with fatty acid instead, suggesting in this case certainly that the fat globules in the epithelial cells were made from absorbed fatty acid. Further, the observation has been made that the fat particles in the epithelial cells are small at the beginning of intestinal digestion, but that they grow larger when the digestion has been in progress some time, as though the droplets were made at the point where they are seen. Again it has been shown that the fat ferment in the small intestine is abundantly able to convert the fat of an ordinary meal completely into fatty acid in the time usually required for a meal's digestion.

However, it seemed difficult to understand how a drop of fat in contact with an epithelial cell was first converted into fatty acid, then absorbed by the cell and, before leaving the confines of the absorbing cell, reconverted into a droplet of fat. But a similar transformation is believed to occur in the case of proteid absorption. Proteids in digestion are converted into peptone and thus absorbed, but no peptone is found in the body, not even in the intestinal blood vessels, hence the peptones must be at once reconverted into other proteids in the act of absorption.

The work of Kastle and Loewenhart makes it clear, in the case of fat, how the reverse processes are brought about. Before referring to their work let us remark that it is well known that the action of ferments is never complete unless the product of the fermentation is removed. To illustrate—if grape juice is fermenting to become wine, the conversion of sugar to alcohol at first may be quite rapid, but by the time a wine of ten per cent. alcohol is formed the alcohol present inhibits the further action of the ferment. If the alcohol could be removed from the wine, the action of the ferment would continue so long as there was sugar present to ferment.

Further, it has been shown that the action of a ferment may be reversible, *i. e.*, that the same ferment which will convert a solution of carbohydrate *A* into carbohydrate *B* will also convert a solution of carbohydrate *B* into a carbohydrate *A*. But, as just mentioned, the action of no ferment is complete, hence whether we start with a solution of *A* or of *B*, the ferment action brings about a solution of *A* and *B* in such proportion that ferment action ceases. *i. e.*, the condition has become one of chemical equilibrium. Kastle and Loewenhart worked with the ferment lipase, whose known action was the conversion of neutral fats into fatty acid and glycerine. They added the ferment to a solution of fatty acid and were able to demonstrate the formation therefrom of the neutral fat.[2] The importance of this observation is very great. First, it adds another to the list of animal synthetic processes. Second, it offers an easily comprehended explanation of the absorption of fat. For in case the small intestine contains neutral fat immediately after a meal, the ferment will soon begin to convert

[2] They employed butyric acid and synthetized ethyl butyrate.

it into fatty acid and glycerine. This action, according to ferment law, would continue till a mixture of fat and fatty acid in chemical equilibrium was produced. But in the intestine, absorption begins and fatty acid is removed as fast as formed, thus allowing the ferment to continue its action as long as any fat remains in the intestine. But if both fatty acid and ferment are absorbed together, then, as soon as they get inside the absorbing cell, the ferment in the presence of fatty acid only will begin its work over again, which then will be the formation of droplets of neutral fat from the fatty acid absorbed.

This view rests on the assumption that fat ferment accompanies the fat from intestine to tissue. The observers mentioned have investigated this subject. They examined a large number of fat-containing tissues and organs, and found in every case that they contained fat ferment about in the proportion that they contained fat, except that the liver contained a very active ferment out of proportion to the amount of fat in that organ.

The fat absorbed from the intestine finds its way into the lymphatics and thence to the thoracic duct, there to be mingled with the blood. Shortly after a meal if the blood serum of an animal be taken and allowed to stand a layer of fat forms on top. The serum taken some hours after a meal, on standing forms no such layer, showing that fat rapidly disappears from the blood. And here arises one of the interesting problems of fat metabolism. What becomes of fat when it disappears from the blood and what is the origin of the fat in the tissues? A very simple explanation would be that the fat of the blood is deposited in the tissue cells. Another theory, and one that has had the sanction of good authority, is that the fat in the tissues is made there from their own proteid substance.

In favor of the transformation of proteid into fat are usually mentioned the following: In the ripening of cheese, fat is increased at the expense of proteid. In certain damp soils corpses have their proteid converted into a fatty substance known as adipocere. Both of these arguments are somewhat less convincing when it is known that bacteria are the active agents of these changes. As the result of various poisons —notably phosphorus—the liver is found to contain large quantities of fat in the form of droplets in the injured cells of the organ. This has been called fatty degeneration and the protoplasm of the degenerating cells in one stage of degeneration was thought to be changed to fat. On the other hand, it is claimed that if an animal is first starved, so that fat disappears from the body, and then poisoned with phosphorous, no fat appears in the liver. There is too other evidence of an experimental nature to show that the fat of fatty degeneration is fat transported from the usual depots of fat and simply deposited in the degenerating cells.[3] The fat of different animals consists of different proportions of the three common fats, olein, palmitin and stearin. But for each animal the proportion in which the three fats enter into its fatty mixture is fairly constant. Recall the difference between beef and mutton tallow and lard. This proportion of fats being fairly constant for an animal species, it does not change with every change of diet. But if an animal be starved for a time and then fed exclusively on a particular fat, such as some vegetable fat never normally found in the animal, the fat used can be demonstrated as present unaltered in the tissues. The question then of the origin of tissue fat is still somewhat uncertain. It seems safe to say that the fat of the food can be deposited unaltered in the tissues, but that all the fat found in the tissues has had its origin in fatty food is certainly not the case; much of it is made from carbohydrate and some of it may be made from proteid.

Turning to the question of the disposal of fat in the body, we may say that it is completely burned in the tissues and has as its end products carbonic acid and water.

A moderate amount of fat in many tissues, especially the subcutaneous connective tissues, the omentum and tissue about the kidney, is normal, and serves as a store of energy, as a protective covering to the body and to retain the body's heat. But there are many persons in whom this amount is excessive, that is, in no way proportioned to their needs. In seeking an explanation of these cases we are at once struck with individual differences. For instance, one sees persons over whose bodies there is a uniform thick layer of fat; they are of florid complexion and many of them active persons. The term corpulent applies to them better than obese, since their bodies exhibit both an increase of fat and of protoplasm and their blood is of normal specific gravity. In the presence of a good digestion and abnormal appetite, they daily consume more food energy than the daily expense of energy requires. The excess is laid away as tissue proteid and fat. A moderate diminution in food taken with some increase in exercise would rectify the condition. But it is almost a waste of words to tell a man to eat less in the presence of an excellent appetite and digestion.

There are other persons in whom the picture is quite different. The fat is not uniformly distributed, but is largely abdominal, the arms and legs being little enlarged; they are pale, and blood examination reveals anemia and diminished specific gravity of blood. Herter calls attention to the rather striking parallel between this condition and diabetes. In diabetes there is an excess of sugar in the body tissues. This has been shown not to be due to any increase in sugar manufacture, but to

[3] The question of the origin of fat from proteids is ably discussed by Henry A. Christian, M.D., 'Some Newer Aspects of the Pathology of Fat and Fatty Degeneration,' *Bull. of Johns Hopkins Hosp.*, January, 1905.

an inability of the body to oxidize the sugar. In diabetes the excess of sugar then is removed by the kidneys. In obesity the fat is not removed, but accumulates in adipose tissue. The explanation of both conditions would be an inability of the body cells to oxidize these substances. Herter states the points of similarity of the conditions thus:

1. Diminished oxidation of both materials.
2. The two conditions are frequently associated.
3. In each case the defective utilization of nutritive materials is more or less closely associated with substances produced by certain glands. It has been clearly proved that disease of, or removal of, certain groups of cells imbedded in the pancreas, known as the 'islands of Langerhans,' cause the appearance of sugar in the urine. And no doubt remains that many of the cases of diabetes are primarily disease of the pancreas. On the other hand, obesity may depend on the suspension of function of other glands. The removal of the sexual glands is commonly, though by no means invariably, followed by the laying on of fat. This fact is taken advantage of by the poultryman in supplying capon for the market. Members of the human species may be similarly affected.

But the gland showing the most intimate relation between its function and obesity is the thyroid. This gland is situated in the neck, on either side of the trachea. Its enlargement constitutes goitre. Its absence or disease result in cretinism and myxœdema. When portions of the dried gland of a sheep are mixed with the food of the normal or obese individual marked bodily changes result. The results of thyroid feeding in men and animals have been well summarized by Richardson.[4] In the first place, there is a marked increase of oxygen consumption and carbonic acid excretion, that is, some constituent of the gland promotes oxidation. This is accompanied by a loss of weight.

The oxidation is not, however, selective of the fats alone, for most observations have shown that there is an increase in the elimination of nitrogen. This would mean that proteid is being consumed as well as fat. If an animal was in nitrogenous equilibrium at the beginning of the experiment, we should expect it to be considerably weakened by its consumption of its own protoplasm. If, however, the nitrogenous food is increased, while thyroid substance is being fed to the animal the condition of nitrogenous equilibrium can again be restored, and the subsequent loss of weight will be due chiefly to the oxidation of fat. The above statement makes it clear that the question of the amount of fat in any individual is a very complex one, depending on such a variety of factors as condition of digestion, appetite, character and quantity of food, amount of exercise and the proper working of a number of body glands.

[4] 'The Thyroid and Parathyroid Glands,' Hubart Richardson, 1905.

NATIONAL CONTROL OF INTRODUCED INSECT PESTS

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THE boll weevil in Texas and the gypsy and brown-tail moths in New England are raising some points in the relations between the states and the federal government in insect control which seem to involve new principles, whose discussion may not be untimely.

Here we have insects which the infested states fail to control, either through inability or neglect, and they spread beyond their boundaries. Quarantines against them are comparatively useless, unless the insects are controlled in the badly infested regions. But why should one state tax itself to subdue a pest which is causing it loss and others gain from increased prices, as in the case with the cotton boll weevil, to prevent it from spreading to them? On the other hand, if it is possible for the state to do so, is the national government justified in assuming the task if it had the authority? Congress makes appropriations to aid in the study of insect pests for the information of the inhabitants of uninfested states, but can it legislate so that a federal official may have authority to proceed in preventing the introduction, or exterminating or controlling any pest which threatens to invade other states and to seriously threaten their welfare? These are new entomological questions of a broad nature which circumstances have forced upon us and which must be solved in the near future.

The writer's first impression, which seems to be the prevailing one, was that the federal government has no authority to make any regulations toward exterminating or controlling an insect pest within a state, except under the laws of that state. Further study of the subject, in relation to the federal control of similar matters of public health and welfare, has forced the conclusion that this view is essentially incorrect and that the national government may have full authority conferred upon it by congress under the constitution for handling the whole situation.

A few points concerning the history of legislation against insect pests in this country may be mentioned to show its present status. Legislation against insect pests in the east was undoubtedly brought about by the introduction and dissemination of the San Jose scale on nursery stock in the early nineties. State after state passed laws concerning nursery inspection and the importation of nursery stock and some concerning inspection of orchards, etc. Some were good; others bad. Confusion for the nurseryman resulted. In late years we have been engaged in attempting to secure as much possible uniformity in these laws, in which the organization of the National Association of Horticultural Inspectors has been of the greatest value. From the first it was seen that the matter of the control of nursery stock was properly a matter for control by the national government, being strictly a matter of interstate commerce. As a result, on March 5, 1897, there assembled in Washington, D. C., a National Convention for the Suppression of Insect Pests and Plant Diseases by Legislation. This convention represented the horticultural and agricultural interests of the entire country. It recommended a measure to Congress empowering the Secretary of Agriculture to establish an inspection of all importations of nursery stock, plants, etc., into the United States, and of all which were subject to interstate commerce, and also drafted a suggestive outline for state legislation upon the same subject. This proposed legislation seems to cover the matter of the inspection and control of insects disseminated on nursery stock, plants, etc., in a most satisfactory manner, though some minor points might now need modification. At this convention Dr. L. O. Howard, entomologist, U. S. Department of Agriculture, presented a paper, in closing which he is reported to have said, that it was "his firm conviction that the establishment of such a service at the eastern ports . . . would many times repay the horticultural interests of the country." In the next 'Yearbook' of the Department of Agriculture for 1898, in a most interesting and valuable article upon the 'Danger of Importing Insect Pests,' Dr. Howard again urged the importance of such legislation. He said:

> The remedy for this condition of affairs is obvious. Laws must be passed establishing a system of inspection of dangerous classes of merchandise, just as has already been done in the case of live stock, and just as has already been done in a partial way by the state of California. The passage of some such national measure as that recommended by the convention of horticulturists and agriculturists held in Washington, D. C., March 5, would seem, from a consideration of the facts here presented, to be abundantly justified by the constant danger which threatens our agricultural and horticultural interests.

The writer is not familiar with the inside history of the work of the committee on legislation appointed by this convention. In any event nothing came of it. The impression is general that the matter at first received the opposition of influential nurserymen. Later, however, when it became necessary for the nurserymen to comply with many and diverse laws to their great inconvenience and annoyance, they evinced interest in securing national legislation on the matter. The chairman of their committee on legislation recently expressed his earnest desire that national legislation might be enacted upon the subject, but after practical experience in presenting the matter to congressional committees seemed to feel that there was but little prospect of securing such attention in the near future. There seems to have been no serious discussion of the matter by any entomologist since Dr. Howard's article in 1898.

In many states the nursery and orchard inspection is now handled by separate state officials, relieving the entomologists of the experiment stations and state entomologists of this onerous police work. But in many states it is still a burden to the entomologist, who would prefer to devote his time and thought to problems of research. That this work has impeded the development of economic entomology in many respects can not be doubted, though, on the other hand, it has undoubtedly had the effect of bringing many entomologists into closer touch with the people whom they are trying to serve. It would seem, therefore, that the entomologists of the country should be most interested in securing national legislation for this phase of insect control at least. That it is perfectly constitutional and practicable can hardly be doubted. The present work could be accomplished with much more efficiency, with greater protection to the horticultural interests and with far less annoyance to the honest nurserymen of the country, and probably to the greater detriment of the nurseryman who fails to clean his premises of dangerous insect pests and plant diseases.

But at this same national convention of 1897 a resolution was passed concerning congressional appropriation to aid Massachusetts in its fight against the gypsy moth as follows:

> *Resolved*, That this is a question of national importance, and that the national government should assume the work of extermination or render substantial financial assistance to the state of Massachusetts for that purpose, that the work may be carried to a successful conclusion and this continent be thus saved from the ravages of another terrible insect pest.

In passing this resolution, the convention recognized the responsibility of the federal government in protecting the uninfested states from the spread of the gypsy moth, which by precedent would involve the same aid for all other insect pests of sufficient importance. It is in this phase of the question that New Hampshire is now particularly interested. By means of an appropriation from the state legislature which would not be burdensome, and which will no doubt be made at the next session, we can probably prevent the spread and increase of the gypsy moth in New Hampshire by annual inspections along all highways liable to be infested. But without the expenditure of a very much larger sum, and in a more efficient manner than is now possible under the present law, by the state of Massachusetts, it may be but a few years before the gypsy moth will be so abundant in Massachusetts up to the New Hampshire line that it will be practically impossible to prevent its spread or to control it in New Hampshire. New Hampshire is thus ultimately helpless to prevent the invasion of the gypsy moth and the possible destruction of her grand old elms shading the highways, or to protect her important lumber interests and forest-clad mountains, the features which make the state one of the most beautiful and attractive in the union, unless Massachusetts may be aided by liberal appropriations from the federal government, so that the further spread of the pest may be checked and be increasingly controlled where it is worst. To this end bills have been introduced during the present session by Hon. E. W. Roberts, of Massachusetts (H. R. 285 and 286), appropriating $250,000 for the extermination or control of the gypsy moth and $15,000 for the importation of parasites and predaceous enemies, to be administered by the secretary of agriculture. This measure has the support of New Hampshire and all the best interests of New England.

But though this appropriation is necessary for immediate use, it seems that the whole matter of the relation of the national government to the control of insect pests is in an unsatisfactory condition. Who can guarantee that this appropriation will be repeated? How can it be administered under present laws, except through the officials of the state of Massachusetts? In New Hampshire there is no legislation upon the matter at present, and any action would have to be done entirely with the permission of property owners, and by the approval of the governor, as at present no damage to property would be involved. If the national government has the power to make an appropriation for this purpose why has it not the right and duty to provide the proper machinery for its administration whenever the necessity may arise from other pests in various parts of the country, without special subsequent action of congress authorizing the same, and if congress has such prerogatives, why should they not be exercised for the benefit of the agricultural and horticultural interests, as well as those of the city trees of the entire country? To show the propriety, feasibility, and desirability of such legislation is the writer's purpose.

That national control of introduced insect pests would be of the greatest value can hardly be doubted after a brief glance at the history of the worst introduced insects of the last twenty-five years. Had there been a federal official with authority to proceed and stamp out and control the San Jose scale when it first appeared in the east, could not its spread have been to a very large extent prevented, if not indeed entirely stopped? Or similarly, if a federal official had commenced the extermination or control of the gypsy moth in the eighties before it was taken up by Massachusetts, and had supervised the work of that state, being ready to step in and prevent its subsequent spread sufficient to endanger the neighboring states, would not the alarming conditions now existing have been to a large extent prevented? The same is true of the brown-tail moth. The Gypsy Moth Committee of Massachusetts fully appreciated the danger of this pest, which in many respects is worse than the gypsy moth, but they had no funds with which to combat it. Later a small appropriation was made, but it was entirely inadequate and too late to control the pest. Had the money been available when the brown-tail moth was first discovered, and had it been efficiently administered, we have no doubt that it might have been effectively controlled. How much loss it will now cause in years to come is entirely problematical, unless the European parasites become of immediate value, for there is nothing to prevent its spread over the entire east within a few years. Last year it spread over one hundred miles in New Hampshire. Again, when the boll weevil was discovered in south Texas, a representative of the United States Department of Agriculture appeared before the legislature of Texas and advised legislation which would prevent the growing of cotton in the infested counties, which grew but a small amount, for a few years, so that the pest might be exterminated, but he was literally laughed down. Had the federal government been able to step in at that time and enforce whatever measures seemed best to prevent the subsequent spread of this insect throughout the cotton belt, the subsequent loss of at least $22,000,000 to Texas alone in 1904 and the present certainly unpropitious outlook for the cotton interests of Louisiana and the Mississippi Valley might have been averted. Might not the introduction or subsequent spread of the miserable little New Orleans ant (*Iridomyrmex humidis* Mayr.), which is now becoming such a nuisance in New Orleans and in southern Louisiana, and whose spread through the south it seems impossible now to prevent or restrict, have been prevented and controlled, had we had such national legislation and organization?

Other instances might be cited, but these are well known to all. Who can tell what pest may not invade some one of our boundary states at any time and increase to such numbers that it will be impossible to prevent its spread before state legislation copes with it? It is to be regretted, but we may as well frankly admit that the present tendency toward federal control of all of these police duties is almost entirely due to the inefficiency of most of our state legislatures in dealing with such matters. Until very recently the states have been very reluctant to delegate any power to make and enforce regulations to any board or official. In doing this the Gulf states in general have the most desirable type of entomological legislation, permitting effectual work against any insect pests which may arise. In most of the states which have legislation upon insect pests, the official administering it is hampered by petty restrictions, and has no funds at his disposal for coping with any new pest which may require immediate action. The average state legislature is very wary of entrusting such powers to any scientist, assuming in many cases that it knows much more about the subject. The debates of the Texas legislature upon the boll weevil and the information given the writer by some of its members would prove amusing reading to the entomological fraternity. Congress, on the other hand, has consistently recognized that it must depend upon experts in such work and must give them sufficient latitude, so that they can take immediate action when necessity arises. To this has been largely due the efficiency of the federal law in very many matters in which the state laws have been conspicuously inefficient.

How many of our seaboard or frontier states have at the present time any system of inspection which will enable them to prevent the importation of injurious insect pests, or how many, even, could proceed to eradicate such pest when actually within the borders of their state when over a few hundred dollars were necessary for its eradication? California is probably the only state having any adequate machinery for such work.

But it is objected that the work of exterminating an insect within a state would be unconstitutional, an interference with the rights of the state, etc. So it would seem and so at first it appeared to the writer, but the present laws of congress concerning the control of cattle and human diseases and the regulation of the importation of noxious animals effectually dispel this objection.

At the present time the Public Health and Marine Hospital Service has charge of most of the maritime quarantine stations and may take charge of any others it sees fit when they are inefficient under state or municipal management. It furthermore may enforce interstate quarantines, or may quarantine any portion of a state and take such measures as it sees fit to eradicate disease in any locality when the local or state health officials, either through lack of legislation or inefficiency, fail to control disease so that it threatens neighboring states. This has actually taken place in several instances. For a full discussion of federal quarantine measures see an article by James Wilford Garner, of the University of Illinois, in the *Yale Review* for August, 1905, pp. 181–205. At the present time the southern states are petitioning congress for the national government to take entire control of maritime and interstate quarantines, owing to the proved efficiency of the government service in handling the yellow fever outbreak during the past season. Surely there can be no better proof of the desirability of federal control of quarantines than the present attitude of the southern states, for no section of the country has had their experience with quarantines and no section has been more opposed to federal quarantines in the past.[1].

By the Lacey act[2] congress has conferred upon the secretary of agriculture the power to make and enforce regulations to prevent the importation of noxious animals, and this act has now been enforced for five years. In essence the law proposed by the convention of 1897

[1] See the *Congressional Record* of March, 1893, for the lengthy debates in the house and senate upon the present national quarantine law, which was admittedly a compromise measure.

[2] See Circular 29, Biological Survey, U. S. Dept. Agr.

would cover the same ground for the prevention of the importation of insect pests.

But more stringent, sweeping and effectual than either of these laws are those establishing and defining the duties and powers of the Bureau of Animal Industry of the Department of Agriculture.[3]

These laws and regulations empower the Bureau of Animal Industry to inspect all import and export domestic animals and all subject to interstate commerce for dangerous diseases. They empower it to proceed to stamp out such diseases as are deemed dangerous and to purchase diseased animals at a fair appraisal when necessary to stamp out a disease. In this work the bureau may and has repeatedly quarantined different states and sections of states. At the present time, the regulations of the bureau prohibit the movement of cattle from counties south of the Texas Fever Line to other counties within the same state, whether the cattle are for interstate commerce or not. These laws and regulations have been tested in the courts and so far have been held constitutional.

Furthermore, congress appropriates for the Bureau of Animal Industry a sum which is specifically for the control of outbreaks of disease. By this means the bureau was able to proceed at once against the foot and mouth disease in New England in 1902. A deficiency appropriation was at once authorized by the next congress (for \$500,000, approved December 22, 1902), which enabled the work to proceed without delay. A similar amount was included in the regular appropriation for the bureau for the fiscal year ending June 30, 1904, but the work had been so thoroughly done under the previous appropriation for such work prior to that time that but little of the last appropriation of \$500,000 was used. It was a portion of this unused balance, \$250,000, which was subsequently appropriated for the investigation of the boll weevil and cotton culture.

Not only do the regulations prohibit the movement of diseased cattle or any cattle from a quarantined state or section, either by shipment or by driving, but they prohibit allowing cattle to drift from one section to another. Furthermore, any hay, straw or other material which may harbor disease from a quarantined area may be entirely regulated by the bureau.

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[3] See Regulations of the Secretary of Agriculture governing the inspection, disinfection, certification, treatment, handling, and method and manner of delivery and shipment of live stock, which is the subject of interstate commerce, 1905. Issued under authority conferred on the Secretary of Agriculture by the acts of Congress approved May 29, 1884, February 2, 1903, and March 3, 1905—which acts are printed in it. Also, see Administrative Work of the Federal Government in Relation to the Animal Industry, by G. F. Thompson, 16th Annual Report, Bureau of Animal Industry, 1899, pp. 102–125, and Federal Inspections of Foreign and Interstate Shipments of Live Stock, by D. E. Salmon, D.V.M., 18th Ann. Rept., Bur. Anim. Ind., 1901, pp. 237–249.

If, therefore, congress, through these agencies, is preventing the introduction of human and animal diseases and noxious animals, and their interstate movement, and eradicates or controls them in sections where their presence threatens the commerce and welfare of other states, why may not the spread of imported insect pests dangerous to plants be similarly regulated? The writer has studied the principles involved with some care and fails to see that those concerning insect pests of domestic animals and plants are not identical.

An interesting phase of the whole discussion arises from the recent convention of the southern states, which passed resolutions, not only praying congress that the national government take charge of all quarantines, but that it proceed to the extermination of the yellow-fever mosquito. Whether extermination of this pest is possible or not I am not informed. From experience with other insects it would seem doubtful. There can be no question, however, that to control yellow fever the breeding of *Stegomyia fasciata* must be prevented. In the control of yellow fever, the federal government would therefore have a perfect right to proceed against this insect as a menace to human health. We have then the anomalous condition that the national government can control the introduction and spread of insects which affect the health of man and the domestic animals, but that it has no laws against those affecting crops or plant life. Is not the loss to plant life from insect pests far greater than to animal life? How do the values of animal and plant products compare? According to the report of the secretary of agriculture for 1905, the domestic animals of the United States are worth $2,995,370,277 in 1904. There are no figures as to the exact value of animal products, but estimating a similar increase from 1900, they would be worth approximately $2,000,000,000. The total value of farm products are estimated by the secretary for 1905 at $6,415,000,000. Plant products would therefore be worth approximately $4,415,000,000, the ten staples alone being worth $3,515,000,000, while the value of all domestic animals and their products would be $4,885,572,394. In brief, the plant products are more than twice the value of the animal products and nearly equal in value both the live animals and the products they produced. These estimates include the value of the products of so-called 'farm forests,' but do not include the value of lumber or the virgin forests not on farms, conservatively estimated to be worth from three to four billion dollars, nor is the inestimable value of city shade trees and parks considered.

The losses occasioned by insects, exclusive of those to animals and stored products, have recently been estimated by Mr. C. L. Marlatt at $520,000,000, which is entirely conservative.

We would venture the assertion, therefore, that the annual losses occasioned by imported insect pests far exceed all losses of animals from disease and of those human diseases which are subjects of national quarantine. Of course, we can place no money value upon human life, but were that possible, we have no doubt that the loss of plant products from a half dozen insect pests imported during the last quarter century would far exceed all losses from animal and human diseases which within that time have been the subjects of national quarantine.

The gypsy moth at present threatens the welfare of New Hampshire, Rhode Island and indeed of all New England, and, if unchecked, ultimately the whole country. Massachusetts has done, is doing and we believe will do, all in her power to check the pest within her borders. But why should her citizens be taxed sufficiently to prevent its spread to neighboring states? And what recourse have the other states, if Massachusetts does not prevent such spread? It would seem that Massachusetts is maintaining a public nuisance, as far as the neighboring states are concerned, but it is doubtful whether a suit could be entered against her on that ground, even theoretically, while actually it is of course entirely improbable. New Hampshire and other states can not make appropriations to aid Massachusetts. Why, then, is it not the duty of the federal government to protect the interests of the neighboring states by checking the spread of the gypsy moth and aiding in its control? The same reasoning will apply to all other introduced insect pests of serious importance. We should all admit that the federal government may prevent their importation, but some of us would claim that as soon as a pest had come upon the territory of any state, that the national government was then powerless to prevent its spread to other states. This same argument has been fully thrashed over in congress concerning human disease, and the present laws, as above outlined and administered, seem to the writer to have fully demonstrated that the federal government has such a right and may make and execute such regulations as seem necessary.

With such national laws and regulations, we believe that the introduction and spread of insect pests, either by transportation or by natural agencies, could be largely prevented. At present under the state laws they are not and can not be prevented.

Serious consideration as to whether it is not entirely feasible for congress so to legislate as to empower the Bureau of Entomology, or such agency as it may deem best, to make and enforce such regulations as will prevent the introduction and dissemination of insect pests, and to appropriate sums sufficient to allow such work to be done at once without awaiting special appropriations, is therefore urged. Only in this way can we have an efficient means of preventing the future importation and spread of insect pests which, if unchecked, may cost the nation millions upon millions of dollars, as those have done with which we are now familiar.

INDIVIDUAL ADAPTATION TO ENVIRONMENT

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IN a preceding article[1] the author has attempted to show that man, as a result of the development of medical science and education, is approaching his limit in evolution, both physically and mentally. The burden of the argument here was to show that, as a result of the incorporation into his environment of his cumulating knowledge, man's social and economical conditions are continually changing, but that with his increased intelligence he has greater power of adapting himself to the new conditions of life which are inevitably the result. And as soon as man acquired those intellectual and moral qualities which distinguish him from the lower animals, he began to invent weapons, tools and various stratagems to procure food and to defend himself, and was but little liable to bodily modification through nattural selection. When he migrated into colder climates he used clothes, built shelter, made fires. He also aided his fellows and anticipated his future. Selection seized upon intelligence and man was enabled to keep an unchanged body in harmony with a changing environment. Progress implies a continued increase of control over nature, through the gradual acquisition of knowledge of her laws. One of the great fields of acquisition of human intelligence is along the line of human diseases, and the means of combating them. Medical science advanced until at present, through surgery and inoculation, she succeeds to a considerable degree in keeping the race adjusted to its ever changing environment without sacrificing many of her individuals, and, consequently, without bringing about any marked change in the type of the human body. Education, too, succeeds in maintaining the intellectually unfit by adapting them to the environment so that they are enabled to make a living and to bring up a family, thus precluding a rise in the average of intelligence in the race. Man is enabled to advance independently of heredity, and natural selection is cheated out of her work. Man can select everything in his world except his own body and mind. He is born with a body and mind which were developed by natural selection and are naturally adapted to the environment that existed when selection ceased. So adaptation to the environ-

[1] 'Limits of Evolution in the Human Race,' *University of Colorado Studies*, Vol. II., No. IV., June, 1905.

ment in which he is called upon to live (civilization) must be accomplished through artificial means. Physical adaptation, as was shown, must be by means of surgery and inoculation, and mental adaptation by means of education. It is the purpose of this article to consider the processes and significance of this mental adaptation of the individual to his civilized environment.

Civilization implies that each generation is working at a higher environing intellectual, moral and spiritual level, and with better tools, which their predecessors from generation to generation have devised and handed down to the subsequent one with usury. The essential thing in progress is that evolution has been transferred from the organism to the environment and that it is the accumulated social structure which persists. Civilization, therefore, is better characterized as a product than as the continual rise of average intellectual capacity. This product is the mold in which mediocrity is cast, and implies, merely, that the level of acquisition is becoming higher rather than the level of intelligence. The mediocre, and even the mentally poor, as well as the apt, are by means of education adapted to their environment and are thus enabled to survive and to bring up a family. Here, too, natural selection is barred from functioning, and for this reason man's mental evolution tends to a limit. One feature, inevitable in education, and which distinguishes social evolution from merely organic evolution, is the predominant part played by the fittest in raising the level of the less fit.

It is not, however, the motive here to discourage education, nor even to lament the fact that natural selection is thereby barred from further developing human intellectual capacity, but to consider progress as superorganic development of the environment, and education as the means of adjusting man to it. It is the method which most efficiently brings man into vital relationship with his intellectual inheritance, and which enables him thereby most effectively to realize himself, that is the interest here.

In order that the child may be enabled to come into the full and most effective relationship with his cumulative intellectual environment, three things must be fully understood, appreciated and taken cognizance of by the teacher in the training of that child. First, he must consider the material out of which the child is constituted, the clay, so to speak, out of which he expects to mold and build the adult. Secondly, he must know the order of appearance and unfolding of the child's various tendencies and powers, when instincts, interests and capacities appear, and how these can be made to function, if desirable, and become a permanent characteristic of the adult. Or, if undesirable, he must know how to keep those tendencies from functioning, in order to eliminate them and leave the individual as an adult free from their taint. Thirdly, the teacher must know what sort of individual will best succeed as a member of society. This is an innovation; it is but a few years since teachers began to plan the adult the child is to be. But in order to plan an individual who shall be in harmony with his environment when he becomes an adult, the teacher must have an intimate knowledge and insight into the cumulative nature of the environment and the dynamic changes which society in all of its functionings and attitudes continually undergoes.

The first two of these essential qualifications of the teacher were first pointed out in a vital way by Rousseau, but he had no conception of the gravity of the third. Rousseau believed that the various tendencies and instincts as they appeared in the child were cues to what the normal individual should be, and should be seized upon in the educational process and made by habituation a permanent characteristic of the adult. Rousseau's ideas of 'returning to nature' were exemplified in his theory of teaching, and the result of such teaching was portrayed in Emile. This character is in the true sense savage. Not having fallen heir to his spiritual inheritance, he is a babe in his comprehension of the world. With never a passion curbed, he has no power of self-denial, and is blown about by every whim and caprice. Rousseau would observe the child in order that he may not overlook any of these tendencies as they appear. We have an entirely different motive in child observation. These instincts and tendencies are not to us indices of what the adult should be, but we study them and note their order of appearance in order that we may be enabled to exercise greater economy and efficiency in the teaching process. Our ideal is to exercise no faculty nor attempt its development until it naturally begins to function in the child's development. If such instinct or tendency is not a desirable characteristic of the adult the educator plans, then he needs to be most careful to inhibit its exercise. Most instincts are transient, and if given no chance to be exercised, and, consequently, to be developed into habits, they will die out, and it is as if they never existed. Instincts afford a wide range of possibilities for the educator to select from in developing the individual whose foundations for manhood he is laying.

When an instinct was allowed to die by not being given provocation to function, that which it would have secured for the individual is to a considerable extent beyond the possibility of acquisition later. For example, when the play instinct appears and the child is not allowed to play, or the play propensities are not called into activity, which is sometimes the case where there is but one child in a family, and where the parents are old and the child is tied, so to speak, to the mother's apron strings, that child, no matter what may be his social advantages later, will never be able to acquire that social poise which the other adults possess as a result of the exercise of play tendencies when they normally appeared. On the other hand, when that cruelty instinct, which almost invariably appears at a certain age in every child, is put into a favorable environment, so that it functions and is fastened as a permanent characteristic upon the individual, no matter under how wholesome moral influences he may be thrown in later life, there is there a tendency to cruelty which can hardly be eradicated. It is likely because this instinct is allowed to function in so many children that there are so many cruelties exercised and murders committed in adult life.

Those instincts and tendencies of the child in its various stages of development are not indications of what the ideal individual ought to be, but are, on the other hand, a portrayal of the history of the race. They appear in the order in which they functioned virtually, and were, therefore, seized upon by natural selection in the order in which their possessors were rendered superior to their fellows as a result of their functioning.

As a result of conditions which are inevitable in a civilized community, such as prevail where there is sympathy and conscience, the intellectually and morally, as well as physically, fit raise the level of the less fit and unfit, so that they all are enabled to have offspring and to have their descendents maintained, natural selection ceases to function and physical, mental and moral evolution in the race consequently ceases. All the instincts, or at least many of them, continue to appear, just as the physical disharmonies continue to appear; and as surgery must get rid of these disharmonies (such as the appendix) in each individual, so must education rid the individual (and each individual) of these tendencies which throw him out of harmony with the present mental and moral environment.

Now the third essential qualification of the teacher, that of understanding the dynamic nature of society and progress, is indispensable. In planning and deciding what sort of a man I want my boy to be, if he is to be completely adjusted to his environment, and consequently to get the most out of life, I must in all respects be able to see into the future and to anticipate the conditions when he is to be an adult. I must, in other words, understand the nature of the change which conditions undergo in the meantime. To illustrate, suppose I am living at a time when typesetting is a good vocation. A typesetter has shorter hours and better remuneration than any other artisan. I plan to make my boy a typesetter. He, as a result of my careful training, develops into an efficient typesetter. He obtains a place and good wages. He marries and by the time he has a good-sized family depending upon him, some one comes along and invents a typesetting machine. He loses his position. He is obliged to serve as an unskilled laborer, probably for the remainder of his life. He is to a considerable degree thrown out of harmony with his environment, and his attitude toward the world is not very wholesome, because of his mal-adjustment to it. He feels that the world is growing worse because it is now hard for him to make a living. Man tends to realize himself only in so far as the conditions remain the same during the period of his application as they were during his period of preparation and adjustment.

The same tends to hold true in the intellectual world, and it seems that Osler's point of view is not without substantial support. The world as a whole continually moves forward in its general notions about things. The individual tends to lag. The professional man, even the scholar, in his point of view, in his way of looking at things, tends to become fixed. The lamentable consequence is that, like the type-setter, his services to society ultimately become less and less useful and vital, and he likewise loses his position, and is supplanted by one who has the vital point of view. It is a daily occurrence that a teacher's, a minister's a professional man's, even sometimes a college professor's, services are no more wanted.

The question comes, can the scholar keep abreast with the times? The most strenuous effort will almost invariably fall short of its attempt. Our ideas integrate into a system. An apperceptional something functions in all intellectual life. The ideas in our minds are the standards by which we receive new truths and ideas. We crystallize into our notions about things; in other words, we form habits of thought as well as of action, and thus become fixed in our theories and attitudes. Considering, therefore, the fact that every subsequent impression upon the mind of a person is viewed in the light of what is already in the mind and fixed, it is not difficult to see why it is almost impossible for that mind to accept an entirely new point of view, no matter how reasonable that point of view may seem to one whose ideas as standards are in consonance with the new view-point.

Ofttimes it happens, however, that scholars are far ahead of their times. They are dreamers or prophets. They anticipate a more or less distant future, and their thoughts and standards all integrate into a system consistent with their point of view. There are only a few whom they can interest in their lofty conceptions. The man most popular in his time is he who gives expression to what the world gropes after, who lives what they feel, who makes their felt wants real. But the environment, intellectually as well as physically, is cumulative, and soon society will have outgrown him. He becomes obsolete. He has given them the means of stepping beyond him to a higher interest. They are now shouting to another hero who is helping them still another step higher in realization. The world keeps on shouting, but continually to new individuals.

Individuals ofttimes in their popularity pass downward in the ranks of society. A man gives expression to something only the elect can comprehend and appreciate; soon classes attain to it and then the mass. Darwin and Spencer, here, are good illustrations. Such individuals may give expressions to things which are universal and consequently are vital for all time; or merely to conditions, the expression of which is the beginning of their fulfillment.

In conclusion, there are elements in character and habituation which are universal just as there are universals in expression. But as a result of the ever-changing conditions to which man is subjected both economically and ideally, he may be in complete harmony here and now with his environment, and as time passes, because of the nature of habituation and ideation, he is less and less able to keep in complete consonance with the spirit of the times. If, however, one understands the nature of the changes which society undergoes he can adapt himself to those consistent changes and thus avoid becoming soured. It is only as the principles of evolution are consciously seized upon and applied to personal life in society that individual adaptation will be facilitated and adjustment automatized.

THE DISEASE AND THE REMEDY

By ALFRED E. P. ROCKWELL, M.D.
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WE stand in this country on the threshold of a great civic awakening, a great economic renaissance, and we should hasten to forge from every opportunity offered by public sentiment, some substantial token of a larger and more exalted citizenship.

Government is the means by which the will of the people finds expression, and in a republican more truly than in any other form of government the character of the laws, and the efficiency with which they are administered, justly interpret the character and enlightenment of the average citizen.

The evolution of the individual, in proportion to the opportunities which the times afford, the suitable husbandry of the public purse, the proper development of natural resources, the conservation of human energy, the time required to convert what is known as public sentiment, all make it imperative that we now lay the foundation for the more efficient application of those principles which have been found best calculated to further those ends.

The physical, mental and moral qualities of the average citizen should be the unit of measurement upon which all estimates of national wealth, wisdom and virtue are based. The nearer these three personal qualifications approach perfection the greater becomes the value to society of the individual, and so intimately are they associated that derangement in one of these spheres is productive of more or less disturbance in the others.

Good physical health is the foundation upon which the mental and moral natures are built. Physical deficiencies in a large measure are responsible for mental and moral defects.

Every human life should be an asset of the nation; an asset the value of which should be determined by its productivity. By productivity is meant every exercise of creative, constructive power in the physical, mental and moral spheres. The highest productive potential is developed from the proper combination of two factors, in the creation and operation of each of which both the individual and the state share certain responsibilities. In the wholesomeness of the moral stamina, the efficiency of the mental equipment and the extent of the physical energy we find the first factor, and may measure the worth of those qualities which the individual is in honor obligated to contribute to social progress, and for the attainment of which he is largely to be held accountable.

It is the duty of the state, on the other hand, to furnish as the second factor the best possible environment for the cultivation of those attributes, which will secure to him, his neighbor and posterity the largest measure of 'life, liberty and happiness.'

Obviously, then, the best interests of both the state and the individual are mutual, and the benefits derived by each from the faithful performance of duty are reciprocal. The individual and the state can not be divorced.

Every human life, however, is not an asset. All lives at some period are not only non-productive, but are the source of considerable expense to the state or relatives and friends, and each unproductive life becomes a proportional burden upon all productive society.

The chief cause of unproductiveness in the adult is inefficiency, and the chief cause of inefficiency having been found by competent investigators to be disease, we must feel that health and disease have too long been considered from the narrow standpoint of an individual blessing or calamity. As our commercial and intellectual activities increase, our socio-medical problems have been multiplied until it has become imperative that we view them in their economic aspects and deal with them accordingly.

To the ultra-conservative or the uninformed it may appear that the elevation of preventive medicine, in its largest and most comprehensive sense, to the importance of a great economic issue, is a step unpractical if not unnecessary.

If, however, under the conditions which now prevail, we add to the cost of human suffering, mental and physical, the financial cost of disease to the individual and to the state in the maintenance of hospitals, asylums, jails, permanent and periodic quarantine regulations with their accompanying commercial disturbance, and then subtract from this total the cost of those diseases which, in the present light of science, are known to be preventable, provided adequate prophylactic measures can be enforced, we shall readily discover in the remainder the warrant for presenting this subject in the dignity of one of national economic consequence.

If adequate relief is to be rendered, it is necessary that ultimate, not proximate, causes and remedies be sought. We shall, therefore, undertake to view in a full yet not extravagant light the terms and factors with which we must deal.

Few people realize the value and importance of a human life. If its value were better understood, a very different conception would prevail regarding the necessity of certain measures, which thoughtful and far-seeing persons are endeavoring to call to popular attention.

The courts have arbitrarily placed the value of one productive male at \$5,000. This is estimated on the basis that the interest on \$5,000 at six per cent. is \$300, the amount of wages which a man would earn at \$1 a day for three hundred working days. If then, the husband of a family is killed by the railroad, and his wife secures a judgment of \$5,000, it is believed that she has obtained in this sum the equivalent of his services to her and her children. This is not true. That life was worth more than \$5,000 to the family and to the nation. Few common laborers in this country to-day earn less than \$1.50 per day; for three hundred working days this would be \$450, which is 6 per cent. of \$7,500. But the wife in these days could not obtain 6 per cent. interest on this sum in any safe investment. We will not here speak of the progressive increase in the cost of living compatible with the maintenance of self respect, a very important consideration. If she could safely secure, in the Eastern States, at least, 4 per cent. she could consider herself fortunate, and if the judgment instead of \$5,000 should be \$10,000, this at 4 per cent. would not amount to her husband's annual wage.

In the case of the death of a mechanic earning \$2.50 per day, the loss to the family and the state, computed on the 4-per-cent. basis, would be represented in round numbers by the sum of \$19,000. As we advance in the social scale we find that intelligence begets increased productivity, and increased productivity in the individual represents to the state and to the family, the social unit, greater monetary value as an asset.

Some lives are of much greater value to society than are represented merely by their physical and mental creative powers. How are we to estimate the value of such lives as Lord Lister, Lady Henry Somerset, Lincoln, Clara Barton, Edward Everett Hale, Charles W. Eliot, Andrew Carnegie, Bishop Brooks, Ralph Waldo Emerson, Tolstoi? Not in the value of their actual physical and mental productivity during life can the estimate readily be made. Not even in the value of the force of their example alone, but in the great impetus which such personalities give to the realization of high ideals, the purification of social and political life, and in the betterment and advancement of the race are we to look for a just estimate of their worth. A worth which it is impossible to calculate on a commercial basis. Yet these units are subjected to practically the same chances of infection from contagious diseases, and countless other dangers, as the average citizen. It is not the duty of the state to provide special means for the protection and preservation of such lives, but to institute such general measures as will reduce to the minimum such agencies as menace all human life, thus saving to the service of the state lives of all classes of society, the annual ruthless waste of which now amounts to hundreds of millions of dollars in value. It is beginning to be understood that, from the monetary standpoint alone, the value of a productive male life to the state is even greater than its value to the family dependent upon that life. The state makes a financial investment in every life, and every day the amount of that investment is increased, and every day the value of each human life should be greater than ever before. In other words, it costs the state a number of hundred dollars (in Massachusetts about $500), to educate alone, and rear to the normal producing age each human life, and when a life is lost much more is lost in addition to the sum invested and the compound interest thereon. That life can never be replaced. Its power to produce is gone forever, and no one can take its place. All others living and to be born have their own work to do, must bear their proportional part of the state's burden.

The causes contributing to impair the quality or shorten the period of productiveness in the individual may be classed as preventable and unpreventable. Those included in the latter class are storms, floods and other forces of nature, unforeseen accidents, the few unpreventable diseases, and like fortuitous conditions. Among the preventable causes of unproductiveness we find insanity, crime, preventable diseases (contagious and otherwise), unsanitary factories and schools, bad sewerage, poor water supply, and the like.

The efficiency of a life becomes impaired and is a potential social burden through disease. Disease is a deviation from the normal, and is now understood to mean more than mere physical disability, for individual and national productiveness is found to be impaired through the manifestation of disease in three forms: First, poor physical health, largely the result of preventable diseases; second, poor mental health, insanity for example, the cure for which lies in the direction of its prevention; third, poor moral health, as illustrated in the various forms of what is called crime, most of which can be prevented.

We have seen that the causes contributing to a greater or less impairment of individual usefulness are of fundamental importance, and universal in their distribution, and any remedy which is to be successfully and economically applied must be likewise basic in character, and of sufficient scope to meet the conditions present.

It becomes incumbent upon us then to strive to raise the standard, physical, mental and moral, of each voter, thus expediting the task of showing him the importance of the relation between the activities of the state and those of the individual.

For generations we have waited, and are still asked to wait, for our school children to develop and rise to carry these burdens; to improve politics; to enact more righteous laws; to secure to the people a more uniform and beneficent government; and we forget the while that when they leave, with meager education, the public school, they must immediately plunge into the breadwinning maelstrom to emerge the same fatigued, misguided voters that their fathers are. Much of the information which it is essential that the intelligent voter possess, in order that he may make the most of every day in his life, can not be taught by the public school system. First, because the amount of knowledge which they are obliged to purvey is so great that the entire public school machinery is already overworked, and they could not, even if they thought it feasible, install the necessary equipment to extend their labors to other fields. Second, because the juvenile mind is not capable of weighing and determining matters of economic importance.

A large proportion of our voters, after securing a rudimentary education, are obliged to labor, and fail to pursue further the studies begun. They seldom read anything save a more or less misguided, hysterical and misleading newspaper. The fatigue resulting from daily physical labor is not conducive to intellectual activity in the form of instructive reading at night, and hence we find our average voter growing up woefully ignorant of the essentials of good government, and dependent, as already indicated, upon self-interested, irresponsible and unreliable sources for his misinformation.

The great disease at the root of almost all evil is ignorance, and the remedy is education. Were it not for ignorance, that universal malady, it would not be possible for so many agencies to exist which diminish the happiness and its corollary, the producing capacity, of the race.

In the supplemental education of the laboring adults upon a broad and practical basis rests the remedy for the present unhappy condition. A large proportion of our countrymen fail to keep abreast of the times in their methods of thinking and of living, because the demands which breadwinning makes upon their strength and time prevent their obtaining authoritative information on the thousand and one subjects, a knowledge of which would lighten their burden and brighten their pathway.

If it can be borne in upon the public mind that many diseases can be avoided, that the amount of insanity can be reduced, that crime with its great attendant expense can be decreased, that the producing capacity of man can be increased, while augmenting at the same time the number of his comforts and the extent of his leisure, there will be a demand for something looking toward relief, and almost any reasonable measure will be actively supported.

Information of the sort needed to secure the interest and cooperation of the voter, whose support is essential to the accomplishment of his own betterment, must be easily accessible, and presented in a form sufficiently authoritative and attractive to insure its reception and assimilation. He does not know that if it were possible to precipitate upon society any of the millennial measures which are frequently advocated by a certain class of agitators, confusion, anarchy and woe would result. It would not be possible for man to adjust himself to new conditions so suddenly thrust upon him. He must be shown that only by advancing step by step along evolutional pathways already well defined, can permanent progress be made, knowing that any radical departure therefrom inevitably invites disaster.

We are confronted with a profound economic problem, and for its solution federal authority and machinery are necessary. There should be established by the federal government a Department of Public Betterment, which should consist of a board known as the Board of Public Betterment, appointed by the President, together with a cabinet officer known as the Secretary of Public Betterment, to be selected by the President. Their entire time should be devoted to this department, and a salary sufficient to insure this result should attach to the position.

In personal character they should resemble the personnel of the United States Supreme Court, and should be selected from the country at large with special reference to their high intellectual attainments, and with the view of associating together men who severally are authorities upon pedagogy, medicine, economics, industrial problems, finance, and similar interests which affect every citizen. In the interest of convenience and economy the work of the department should be divided between two bureaus. One for the accumulation and classification of knowledge valuable to the department, which might be known as the Bureau of Research of the Department of Public Betterment, and one designed to disseminate and apply the knowledge thus obtained, which might be known as the Bureau of Publicity of the Department of Public Betterment.

It should be the function of the former to ascertain the causes of diseased conditions, and search for the prevention of those causes. It should investigate, compile and supply data relative to the numberless problems associated with municipal government, crime, insanity, immigration, child labor, the length of the working day, the preservation of the sabbath day, and extension of holidays; the construction, ventilation and sanitation of public buildings, and the vehicles of common carriers; educational hygiene; modern philanthropic methods, idleness, divorce, marriages against public policy; public institutions, their character, establishment and administration; strikes, commerce and the like.

The Bureau of Publicity of the Department of Public Betterment should be empowered to institute such measures as seem wise to correct the evils above indicated. It should have authority to prevent the spread of diseases; to stop the publication of indecent literature; to close all factories producing injurious foodstuffs; to divorce politics from the public schools, to deal vigorously with the tenement-house problem, the liquor habit and like evils which impair individual, and consequently national, health and productivity. In the event of pestilence, famine, flood, drought, war, or any similar calamity in any part of the land, it should be the function of this bureau to render immediate assistance as required. This bureau should have power to appoint from time to time as needed competent tribunals to adjust and prevent strikes and the like, selecting for service men especially fitted to deal with special conditions as they may arise.

The Bureau of Publicity of the Department of Public Betterment should organize a corps of lecturers, the men composing which should be recognized authorities in the departments of knowledge which they severally represent. They should be selected with the greatest care. The highest authority on a given subject would not necessarily be the most useful lecturer for the department. The best man for the purpose of this plan would be one who has the gift of conveying in comparatively simple and concise English scientific facts, and who, withal, is an attractive and entertaining speaker. Excessively technical treatment of any subject would soon result in empty lecture rooms. To understand the need for, and the appreciation by the public of, such free lectures as here contemplated, one has but to familiarize himself with the history and operation of free lecture courses as given in some of our large cities. It is idle to address people on subjects which do not interest them, and matters in which the population of one district, affected by a certain combination of conditions, are greatly interested, would not attract the slightest attention in another section of the country where other conditions obtain. There are certain subjects relative to personal health, municipal administration, trusts, patent medicines and the like, which should prove popular as material for lectures throughout the country.

The elaboration of a schedule for the suitable distribution of lectures and their varied subjects is but an administrative detail. Some plan incidentally determining the relative popularity of the several lectures upon given subjects would serve as a valuable guide in the matter of their selection. It would also tend to stimulate in each lecturer a desire to improve his matter and his style. At times there would be a greater demand for lectures upon certain subjects than at others. When a city was considering the reorganization of its school system, or the improvement of its water supply, there would naturally, in response to the popular interest in these matters, be a greater desire to secure authoritative information upon these subjects than at other times. In the event of the invasion of the Pacific coast by the bubonic plague, the people of that section would be much more interested in securing instruction for its extermination than the New Englander. Manufacturing interests in the state of Rhode Island would demand in many respects very different treatment from the coal mining sections of Pennsylvania, and each of these would fluctuate in local and general interest.

In short, the Department of Public Betterment should not only stand ready to answer rightly questions of public interest, but, further, take an active part in their just solution and adjustment.

In view of these considerations it would be unwise to keep a fixed number of lecturers constantly employed, but secure, as the demand developed, the men necessary for the work.

It may be urged that the daily press in a measure already does the work aimed at. In reply to this contention, it should only be necessary to call attention to the growing distrust prevalent regarding the reliability of newspaper science and sociology. Moreover, from the earliest times, the instruction given by word of mouth has always been more eagerly sought after, and has proved more fruitful in results than the printed page.

The objection may be raised that political preferment and intrigue will soon permeate, and finally paralyze, the department's activities. In answer to this, we need but call attention to the United States Supreme Court, against which similar prophecies have been made, only to be unfulfilled. No intelligent person has ever entertained a suspicion that political evil ever invaded the sanctity of that august body. If, as is entirely practicable, the same great care be exercised regarding the selection of the members of this board, and the preservation of its political isolation, no anxiety need be felt with regard to its integrity, and the efficient and impartial exercise of its functions.

It should be the duty of the Department of Public Betterment to make a careful study of the needs of the people, and supply them with necessary information whereby they may secure their own betterment. This is now done in a limited way for certain classes. For example, the Department of Agriculture, the annual expense of maintaining which is about $6,000,000, has experiment stations scattered through the land which investigate the special needs of the farmers of different sections, and as rapidly as information is secured it is printed and given as wide distribution among agricultural and similar interests as its character warrants. It is well known that this policy has not only saved to the individual farmer the expense of personal experimentation, but has been the means of enriching him, and has incidentally developed the productiveness and increased the acreage of farm lands of this continent, reduced the price of foodstuffs, and put many millions into the public treasury. Why should not this same thing be done in an appropriate and practical manner for other classes of society, the mechanic, the miner, the laborer, according to their special needs?

It should further be the duty of the Department of Public Betterment to systematize and consolidate, in the interest of efficiency and economy, all efforts now being made to convey to the people a knowledge of how to live better. Many states, for example, spend large sums annually to support a State Board of Health which does much work that is merely a repetition of that done elsewhere, and most of which could be done better and more economically by the Department of Public Betterment.

There is ample excuse for the existence of such a department in this government. There are many odds and ends left over from the work of other departments which could more properly and more satisfactorily be centralized in the department suggested. Much of the work of the existing departments does not properly belong to them, and is, therefore, imperfectly done or periodically neglected. All this should be turned over to the Department of Public Betterment, which should, when properly developed, attain a position of first importance in the federal service, for the extent of the field to which the activities of such a department might be legitimately applied is almost limitless.

It may be urged that we already have local boards of health and health officers, seaboard and other quarantine regulations, general and insane hospitals, laws governing the questions of factory and school sanitation, child labor, the liquor habit, and the like. Praiseworthy and helpful as are the present efforts to preserve the public health, they are entirely inadequate to meet the demands of an ever-progressing civilization.

The officers who have in charge these agencies for the prevention of disease, and upon whose vigilance we are each dependent for our personal safety, even though selected for their good moral character and fitness, are not given the necessary authority and funds to enforce adequate preventive measures, are underpaid and are constantly hampered and humiliated by the intrigue of political meddlers. This is not a suitable system of preventive medicine for a self-respecting and highly civilized republic.

Expensive as may be the execution of the plan herein outlined, its possibilities as an economy in the administration of the state, in its prevention of crime, insanity, costly physical suffering, and the maintenance of the public institutions which these things entail, far outweigh the consideration of the cost of its installation.

It must be remembered that the accomplishment of all these things would not only result in great saving in individual, city, state and national expense, but would further create a more intelligent citizenship, which would, through its own increased productivity, own more property on which larger taxes would be collected and expended for the benefit of all. This should be borne in upon the voter's mind, and when he fully comprehends its real import, true socialism will have been born. Take to the voter a direct and consistent story, show him the ruthless waste of treasure which comes primarily from his purse, point out to him the intelligent exercise of the franchise as the remedy, and improved civic conditions will prevail. But, in order to be helpful and of the highest usefulness, this plan must follow certain well-known laws of social evolution, and paternalism with its attendant subtle evils must be guarded against with the greatest vigilance. And in passing it may be well to register a protest against the present epidemic of uncoordinated, misdirected and impotent 'philanthropy' which, notwithstanding its well-meant purpose, fails to do aught but blight the fiber of the receiver, and fritter away the energies of the giver, thus proving injurious alike to both. Such heterogeneous and pestilential efforts might well be termed criminal philanthropy.

Let the better element in society forget class distinctions, sectional strife, sectarian differences and personal bickerings, and take up seriously the consideration of these problems.

Unless thoughtful persons are prepared to formulate and act as a unit in the furtherance of some such plan as here indicated, it will very appropriately be asked, "If these people who are accredited with possessing superior intellectual attainments, and who profess humanitarian purposes, can not agree among themselves when there are at stake matters of such vital consequence to all mankind, how can they expect to attain their ends, and obtain from less talented persons the cooperation necessary to succeed?"

Nor let us squander our resources in needless discussion and the costly delay it entails. It must be remembered that time also is a national and individual asset, for the proper use of which a higher power is to hold us accountable. When the welfare of human life is in the balance, trivial and senseless controversy is criminal.

Notwithstanding the industry with which the medical profession, already overworked, and frequently grievously misunderstood, seeks to propagate progressive ideas regarding the acquirement and maintenance of health, personal and public, never can a decisive conquest of ultra-conservatism, bigotry and ignorance be made without the active support of thoughtful and discerning people.

THE PSYCHOLOGY OF YELLOW

By HAVELOCK ELLIS

THE part played by red as a powerful stimulant in the psychic life is clearly pronounced and fairly uniform among all peoples at all grades of civilization.[1] The special emotional tone of yellow is by no means so easy to define. It varies to a marked extent at different historical periods, in different regions of the globe, even under civilized conditions, at different ages in the same individual. There is no color which is sometimes so exalted in human estimation and sometimes so debased. The psychology of yellow thus presents problems which are peculiarly difficult to unravel.

Among primitive peoples the delight in yellow seems to be almost universal. Red is the favorite color of savages, but—as in the personal decoration with ochre of the tribes of Central Australia, according to Spencer and Gillen—yellow is easily second, and sometimes perhaps on the same level with red. Indeed, it may even at times seem to be preferred to red. Thus in some parts of New Guinea, although the natives are fond of scarlet, they take the trouble to feed a certain parrot having red tail-feathers on a yellow root (for they have no means of dyeing) until the tail feathers turn yellow.[2] As a general rule, when dyes are known, bright yellow, after or with scarlet, is the favorite color, as it was among the Society Islanders. It was so, not only among the savages of the Pacific, but also among our own ancestors, and the primitive German woman used yellow and red ochre to adorn her face and body.[3] The early Europeans seem to have been by no means always careful to distinguish between their two favorite colors of red and yellow; they saw both colors in gold, the most precious material of their adornments; the phrase 'red gold' is almost modern, and the Kirins of the Caucasus, according to Abercrombie, used for gold a word (borrowed from the Tartars), which also means red.

Young children, who are at one with savages at so many points, share their love of yellow, and usually indeed prefer it to red, though some writers, like Scripture, are inclined to account for this as due entirely, as in large measure it doubtless is, to the greater brightness of yellow. As to the reality of the preference among the children of various nations there seems to be little doubt. Preyer's child liked and

[1] Havelock Ellis, 'The Psychology of Red,' *Popular Science Monthly*, Aug., Sept., 1900.

[2] R. E. Guise, *Journal Anthropological Institute*, Feb., 1899, p. 214.

[3] G. Buschan, 'Leben und Treiben der Deutscher Frau in der Urzeit,' p. 7.

discriminated yellow. Miss Shinn found that yellow was her niece's first favorite color, and, in her twenty-eighth month, she had a special fondness for daffodils and for a yellow gown. Mrs. Moore found that in the sixteenth week her child chose a yellow ball in preference to a red, and, later, in the forty-fifth week, six times out of ten preferred the yellow ball. Binet's child could not readily distinguish yellow, but was especially successful with orange. A lady who made some experiments for me with a Belgian child one year of age found that when successively offered a red poppy and a yellow poppy, then red, white and yellow poppies, finally red, white, orange and yellow poppies, she on all three occasions chose the yellow poppy, though on the third trial she hesitated between the orange and the yellow poppies; when she passed yellow poppies growing she would point to them and want them, and was also observed to contemplate admiringly a sunflower, though usually indifferent to flowers of other colors, except pink geraniums. At this age, no doubt, the preference for yellow is mainly a question of luminosity, for the careful investigations of Garbini on a large number of children showed that under the age of three they may almost be described as color-blind and experience a special difficulty in distinguishing yellow, which even at a somewhat later age is often confused with orange.[4] When children show genuine color preferences, they appear, like adults, to be only to a slight degree attracted by brilliancy, but to a large extent by depth of saturation. This was found to be the case by Aars, who in testing color preferences used colored papers of similar brilliancy and depth. His results indicate that, as Barnes had already found, children's love of yellow diminishes with age; even between the ages of four and seven, though yellow was still one of the most favorite colors of the boys, it had ceased to be in any degree a favorite color with the girls. Lobsien, at Kiel, investigating the color preferences of a large number of school girls between the ages of eight and fourteen, reached congruent results; he adopted the method of offering the colors in pairs, and found that while orange was never preferred to any other color, there was a tendency at all ages to prefer yellow to green and usually to violet, but never to red or blue.[5] These results harmonize with the conclusion of Garbini that in discrimination of color girls are more precocious than boys, though it must be added that, as in physical development, the period of adolescence brings to an end this greater rapidity of girls in development; thus Wissler, in comparing the color preferences of freshmen and seniors of both sexes, found (as Jastrow had previously found) that with age there is a shifting of preference towards the violet end of the spectrum which is the favorite end of men, red being that of women.

[4] Garbini, *Archivio per l'Antropologia*, 1894, fasc. 1.

[5] Lobsien, *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, 1904, p. 42.

Investigations on students in various countries have almost invariably shown that yellow is the least attractive color. In Germany, Cohn found among students that yellow, even in any degree of saturation, was never the preferred color.[6] In determining the color preferences of 100 students in Columbia University, it was found that yellow came, at a considerable distance, fourth, being only followed by green, while Wissler found that, for male and female students alike, yellow is of all colors the least frequently preferred (by two per cent. of the men and five per cent. of the women); among the men it was also the most frequently disliked, though among the women this dislike was transferred to orange.[7] The dislike of female students to yellow, it will be seen, seems a little less marked than that of male students. This is confirmed by an inquiry at Wellesley College, where it was found that though only 10 per cent. of the women preferred yellow, it was yet more frequently preferred than green or violet.[8] At Cornell University, in a series of careful experiments on a small number of individuals, Major considered that there was no evidence of a positive dislike of yellow, yet all his subjects found yellow or orange among the least pleasant colors.[9]

Among adults generally, it must be said finally, that yellow and orange are very seldom the favorite colors, and in ascertaining the color preferences of 4,500 men and women at the Chicago Exposition, Jastrow found that yellow and orange were the least preferred colors, though here also women seemed to like yellow more often than men.

But for mankind in general these results, undisputed as they probably are, do not hold universally good. There is one vast and highly important area of the world, by no means uncivilized in large part, where yellow, so far from being disparaged, is held in the highest honor. Throughout nearly the whole of Asia, ancient and modern—in Assyria, in India and in Ceylon, throughout China, in the Malay peninsula—yellow is usually the supreme and most sacred color.[10] In India and Ceylon yellow is preferred, whether in flowers or in garments, and the substances that produce yellow dyes are held in highest honor and are essential in the ritual of many ceremonies; in the ceremonial of Hindu marriage, for instance, turmeric is always necessary. Turmeric is in India the substitute for the saffron, probably used by the Aryans be-

[6] J. Cohn, *Philosophische Studien*, Vol. X., p. 562.

[7] C. Wissler, 'The Correlation of Mental and Physical Tests,' *Psychological Review Monographs*, Vol. III., No. 6, p. 17.

[8] C. Mills, 'Individual Psychology,' *American Journal Psychology*, 1895.

[9] D. R. Major, 'Affective Tone of Sense-impressions,' *American Journal Psychology*, October, 1895.

J. Jastrow, 'The Popular Esthetics of Color,' POPULAR SCIENCE MONTHLY, 1897, p. 361.

[10] The geographical distribution of the love of yellow has been especially investigated by Arnold Ewald, 'Die Farbenbewegung,' pp. 64 *et seq.*

fore they reached India, which with its brilliant yellow as of the rising sun has been used by the men of many lands from the earliest ages. It was perhaps connected with sun-worship, as turmeric appears to be to-day in India.[11] In Persia saffron possessed magic qualities and even in the medieval Europe saffron was worn in little bags and constantly used in the preparation of food. The Soma, it may be added, is of a golden color and is still used in Persia as a yellow dye. The Buddhists, again, hold yellow in highest honor, and the sacred flower of the Buddhists is yellow. In Persia, yellow is a favorite color, as it was with the Hebrews, for in the *Song of Songs* the bride is compared to saffron. In China, yellow is the fortunate color, though largely sharing this virtue with green and red. In the Malay states, white is holiest of all and is used to conciliate demons, but after white yellow is by far the most sacred color. According to Malay annals, a certain sultan prohibited the wearing of yellow garments in public, and even the use of yellow handkerchiefs or curtains, because yellow is too sacred for ordinary mortals, and ever since yellow has been the royal color in all Malay states.[12] It may be added that on the western borders of Asia, in ancient Egypt, although yellow was not the supreme color, it was still held in high honor; the favorite combination to express splendor was gold and lazuli.[13]

Even in classic Europe, at the highest moments of the civilization we inherit to-day, yellow, though not occupying the sacred position it has always held in Asia, was yet a preferred color, always mentioned with an affective tone of delight. In both Greece and Rome—somewhat curiously, in view of what we have had to note of the psychic reaction to it in modern times—though red was the most sacred color, yellow was the color for the festival garments of women and children, and was especially worn, Pliny states, by women at marriage. It was also the color of the priests of Cybele. Red and yellow, according to the same author, were the colors that dominated in ancient pictures. The four primary colors, according to Empedocles, are white, black, red and yellow, exactly the four colors which Nietzsche, discussing the philology of classic color-words, states that the Greek world seems to have been made of. Yellow was with red the favorite color of Homer, and Latin poetry is specially rich in synonyms for yellow.

What is the meaning of this clash of feeling between the modern European world, on the one side, and, on the other, the ancient classic world and the universal sentiments of Asia? It is not obvious why we should have ceased to delight in a color that to the men of another

[11] An interesting study of the sacred uses of yellow in India has been written by Dymock, 'On the Use of Turmeric in Hindoo Ceremonial,' *Journal Anthropological Society of Bombay*, 1890, pp. 441–448.

[12] W. W. Skeat, 'Malay Magic,' p. 32.

[13] Flinders Petrie, 'Egyptian Tales,' pp. 83 and 95.

age and of another continent has seemed so precious, the color of the sun, of gold and of corn, of honey and of amber. It is still a very familiar color to us, alike in sunlight and artificial light, and when not too intense is in no degree fatiguing to the sense-organs; harmonious tones of yellow, indeed, in the scheme of the decoration of a room, are for many, perhaps for most, people highly agreeable to live in. Nor can we claim that our dislike to yellow reveals a more refined esthetic sensibility than the ancients possessed, for the painter knows nothing of this antipathy. In Rembrandt, indeed, we have a painter of the very highest rank who, as he slowly approached the culminating point of his art, was more and more fascinated by yellow, until in the end his pictures, even his portraits, are entirely covered by the shimmer of old gold.

It was clearly the advent of christianity that introduced a new feeling in regard to yellow, leading, as Magnus has remarked, to a preference for the dark end of the spectrum. In very large measure, no doubt, this was merely the outcome of the whole of the christian revulsion against the classic world and the rejection of everything which stood as the symbol of joy and pride. Red and yellow were the favorite colors of that world. The love of red was too firmly rooted in human nature for even christianity to overcome it altogether, but yellow was a point of less resistance and here the new religion triumphed. Yellow became the color of envy.

In some measure, however, this feeling may have been not so much a reaction as the continuation of a natural development. The classic world had clearly begun, as savages have begun everywhere, with an almost exclusive delight in red, even an almost exclusive attention to it, and for Homer as for the Arabs the rainbow was predominantly red; yellow had next been added to the attractive colors; very slowly the other colors of the spectrum began to win attention. Thus Democritus substituted green for yellow in the list of primary colors previously given by Empedocles. It was at a comparatively late period that blue and violet became interesting or even acquired definite names. The invasion of christianity happened in time to join in this movement along the spectrum—for even in the second century after Christ's birth Aulus Gellius when discussing colors scarcely mentions green and blue —and in doing so christian energy was reinforced by its instinctive repulsion for the brilliant colors associated with pagan rites and customs. Thus it was that not red or yellow, but blue, the hue of heaven, became the traditional color of the Virgin's raiment. In ecclesiastical usage yellow has never been regarded with favor; it has usually been either a color to avoid or to treat with indifference. This feeling has not diminished with the centuries; in 1833 the use of yellow in priests' garments was prohibited, and in the protestant church yellow has never been used at all.

Yellow became the color of jealousy, of envy, of treachery. Judas was painted in yellow garments and in some countries Jews were compelled to be so dressed. In France in the sixteenth century the doors of traitors and felons were daubed with yellow. In Spain heretics who recanted were enjoined to wear a yellow cross as a penance and the inquisition required them to appear at public *autos da fe* in penitential garments and carrying a yellow candle.[14]

There is a special reason why christianity should have viewed yellow with suspicion. It had been the color associated with wanton love. In the beginning the association was with legitimate love; it has already been noted that in classic times the bride's garments were yellow, while in the *Iliad* as well as in the Indian *Gitagovinda,* a bed of saffron is prepared for lovers. But in Greece, and to a still more marked extent in Rome, the courtezan began to take advantage of this association. The Greek hetaira and her Roman successor wore saffron-colored frocks and dyed their hair yellow. That professional custom of dyeing the hair has to some extent persisted, as we know, among their successors for more than two thousand years, throughout the middle ages to the present, and the injunction of Menander (as quoted by Clement of Alexandria), 'No chaste woman ought to make her hair yellow,' has been a perpetual refrain among the fathers of the church. It was as a reflection of the evolution of yellow in this direction that it became the symbolic color of inconstancy and adultery.

The outcome of the history of yellow during these two thousand years has been a curious opposition and contrast in the emotions it suggests. On the one hand, the affective tone of yellow in general has slowly become for most people either negatively indifferent or positively unpleasant. But the primitive and classic glorification of yellow has not absolutely died out. It has only concentrated itself around the word 'golden.' We see this mixed attitude reflected in the poets. They use the word 'yellow' with extreme parsimony as compared with their profuse employment of 'red,'[15] but 'gold' and 'golden' constantly recur, and always with an emotional suggestion of beauty and splendor and joy. This is, for example, very marked in Keats. Even, however, in the use of 'golden,' it is still possible to trace a latent antipathy to the color yellow. In primitive times—among the Celtic makers of the Irish cycle of legends, for instance—it was the color quite as much as the preciousness of the metal that is felt to be desirable. But among our modern poets 'golden' has come very largely to mean what is beautiful or delightful, with little or no reference to

[14] Lea, 'History of Auricular Confession,' Vol. II., p. 87.

[15] Wordsworth seems somewhat to insist on yellow, and shows a special predilection for yellow flowers; it was part of his general scheme in rehabilitating common and despised things. Walt Whitman shows a somewhat similar predilection for 'yellow' and a disdain of the conventional 'golden.'

color. The epithet of 'golden-mouth,' which became the name of the eloquent Chrysostom, shows that 'gold' was used in a highly symbolic sense at an early period in the history of christianity, while Shakespeare's 'golden lads and girls' is typical of this vague poetic use of the word. 'Golden' in English has largely come to mean not yellow or any other definite shade of color, but merely beautiful and precious, as 'red' means in Russia. The same contrast between 'yellow' and 'golden' may be found in other European languages; in French, for example, the affective tone of *jaune* is totally different from that of *or,* and it is the same in Italian and most other allied languages. As a general rule yellow is not applied by the poets to any object which suggests a definitely beautiful emotional tone, while 'golden' only in a minority of cases, as when applied to hair, corn, etc., bears any insistence on definite color.

It is not until the middle of the last century, at all events in England, that we find any definite revival of the old classic feeling in regard to yellow. It is very notable in Swinburne, who dwells with pleasure on honey and amber and other yellow substances, emphasizing their color; yet at the same time he usually avoids the use of the word yellow; 'white and gold and red,' he declares, are 'God's three chief words,' and he marks his sense of the inferiority of the word in the lines:

> A comb of yellow shell for all the rest,
> A comb of gold for the king's daughter.

In the course of centuries and until recent times, we find, there has thus been a gradually diminishing tendency to insist on the color of any beautiful or desirable object that is yellow. At the same time, there has been a tendency to emphasize the associations of yellow, which are really founded on one of the most ancient observations of man. Yellow is the color of bile and of a jaundiced skin. Most of the evil passions and impulses of mankind, in the popular science of primitive peoples, have their origin in the liver and the bile. The degree to which mankind has been impressed by the yellowness of bile is sufficiently proved by the fact that bile has constantly served to supply a name to yellow; thus among the Eskimo, the Chukchis, the Samoyeds, the Voguls and other subarctic races yellow (and sometimes green) are called by a word which means bile.[16] Even in our own Aryan tongues it seems to be the same, and 'gall' lies at the root not only of 'yellow' but also of 'green' and even of 'gold.' Hence it is that yellow is the color alike of envy and of melancholy. We have in Shakespeare's phrase the 'jealous complexion' (orange) and 'green and yellow melancholy,' and in Pope the 'jaundiced eye' to which 'all

[16] W. H. R. Rivers, 'Colour Vision of the Eskimo,' *Proceedings Cambridge Philosophical Society*, Vol. XI., Pt. II., 1901.

seems yellow.' This perpetual inhibition, initiated by the early christians, of the agreeable associations of yellow, and the concomitant emphasis, not only in language but also in actual life, of all its most unpleasant associations, may possibly account for the predominant emotional tone of yellow among peoples of European origin to-day.

A doubt may indeed possibly arise as to the complete adequacy of such an explanation. Can we absolutely exclude any innate psychic tendency physiologically rooted in the organism? A curious circumstance recorded by Latta, in his careful psychological investigation of a man operated on at the age of thirty for congenital cataract, might possibly be held to support the doubt. The first color that the subject noticed on recovering from the operation was red, while green took him the longest time to master. But 'the first time he saw yellow he became so sick that he thought he would vomit.'[17] One might be tempted to regard this incident as a brilliant justification of the association between bile and yellow and of the attitude of christendom towards this color; an adult man, whose visual sense-organs have retained their virginal delicacy, at once becomes 'bilious' when he sees yellow! But, even putting aside the possibility of idiosyncrasy, it is fairly obvious that the man would approach the sight of colors with certain prepossessions; we are not told that he was shown yellow without being informed of its name, and since blind people are interested and curious with regard to the nature of color, we may well believe that this man had imbibed the current ideas as to yellow and that the appropriate affective tone was already associated with the color before he had ever seen it.

However that may be, the strange history of yellow in the human mind and its striking vicissitudes are not only full of interest, but they really bring us up to a great problem which the psychologist must constantly face under a myriad of aspects: the respective parts which must be assigned to the innate properties of the psychic organism and to the temporary reactions it has acquired under the influence of a slowly shifting environment. How far, the psychologist must so often ask himself, am I investigating the intrinsic qualities of the stream of consciousness? How far am I registering the images reflected from its banks?

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[17] *British Journal Psychology*, June, 1904.

BIRD PHOTOGRAPHY IN NORWAY

By Dr. R. W. SHUFELDT

NEW YORK

AS any general reader of the magazines in this country thoroughly appreciates, there has been within the last twenty years a wonderful and widespread interest taken in the matter of photography of birds, their nests and their haunts. There is not a month that passes without some one of the larger magazines, or even several of them, publishing a bird article illustrated with a series of photographic reproductions from nature, and these are often from the pens of our best-known ornithologists. The effect has been that many of our commoner bird forms are now coming to be quite generally known, which was by no means the case forty or more years ago. But the United States does not stand alone in the production of this class of literature, and, old as the old world is, it has not come to be so antiquated that people no longer take any interest in its avifauna; indeed, the old adage that 'familiarity breeds contempt' by no means applies here, for, as a matter of fact, the very reverse of the proverb holds true, and the better we come to know the birds, the more ready are we to recognize the fascination of their closer acquaintance.

Having been a student of the world's ornithology for a period extending over forty years, and a continuous writer on the subject for a quarter of a century, the birds of Europe are nearly as well known to me as those of my own country, and the life histories of some of them mean quite as much to me. In this way I have become as familiar with the birds of a country like Norway as I am with those of any part of the United States, and some of them I have studied quite as closely, their habits as well as their anatomy. Now the Scandinavian camerists have not been idle in the making of life photographs of the birds of the North European region in general and of Norway in particular. Among these workers no one is better known, or more distinguished, than the veteran Norse naturalist, Professor Robert Collett, professor of zoology at the University of Christiania, who has been a correspondent of the writer's since the early eighties. Professor Collett spends his summer vacations in rambling over the most interesting parts of Norway, during which times he captures many bird pictures with his camera. He has kindly illustrated the present article for me and supplied some of the notes.

When one comes to study the land birds of Norway, one soon ascertains that many of them are resident species, a still greater number

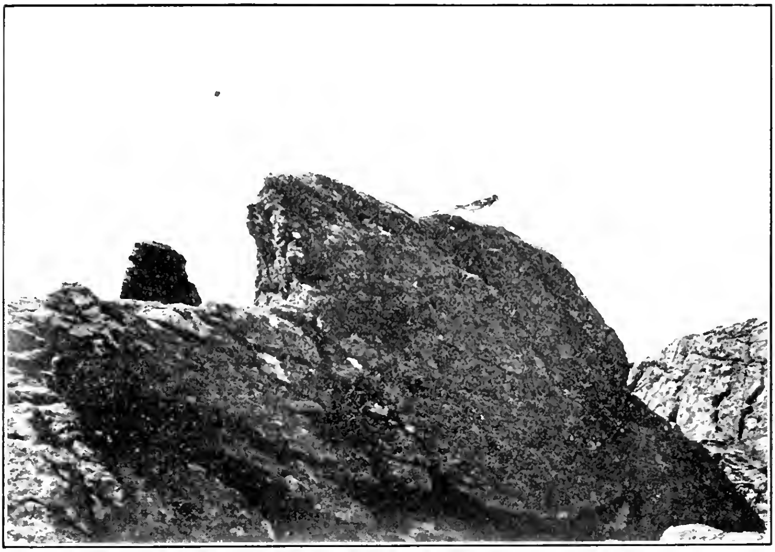


FIG. 1. THE OYSTER-CATCHER IN ITS NORTHERN HOME.

of them are migratory, while still others belong to a small list of 'stragglers,' these last being birds that only accidentally occur there, and which, from one circumstance or another, are visitors by chance rather than by choice. This may happen in any country, as in the case of European birds being found in the United States, or American birds in England or elsewhere. It must be borne well in mind, how-

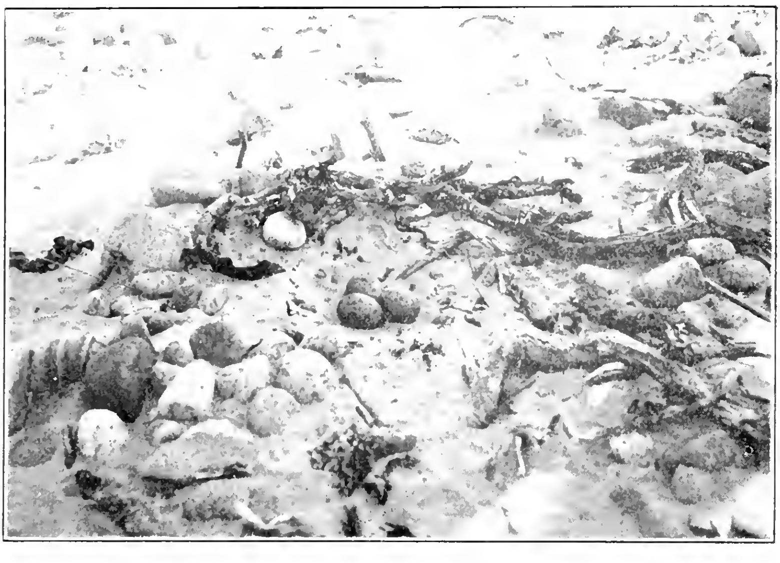


FIG. 2. NEST AND EGGS OF THE OYSTER-CATCHER

Fig. 3. Razorbill Auks. Rocky Coast of Rott.

ever, that such occurrences are but accidents, and at the best extremely rare. The resident birds in Norway are chiefly boreal forms and some few of them are circumpolar in distribution, and are therefore found, not only in this country, but throughout northern Europe and Asia. On the other hand, the migratory land birds comprise those species which during the spring and summer pass up into the country from southern and western Europe, to return in the autumn. Many of these breed there, and their habits are well known to continental ornithologists. As to the water birds, the coasts, inlets, fjords and estuaries of Norway abound with them, as do many of the inland lakes and streams. Some of these numerous species are resident; a large number are migratory; and, as we should naturally expect, 'stragglers' from other lands and seas occur there from time to time. Not a few of the species are common to our Atlantic coasts, and a few others are of almost cosmopolitan distribution, in so far as the northern hemisphere is concerned.

Among the land birds there are represented the thrushes and their allies, various kinds of warblers; the dipper; titmice, nuthatch, the wrens, creeper, wagtails, pipits (one being peculiar to Norway), oriole and shrikes; flycatchers, finches and swallows; crossbills; the starling; crows and their allies; larks; swifts; the nightjar; woodpeckers and wryneck; cuckoo; eagles, hawks and owls and some of their allies, and some few other forms. Then among the game birds there are ptarmigan, grouse, the famous capercaille, quail, doves, woodcock and others.

Passing to the water birds the list is still more varied. There is the gannet and two species of cormorant; several waders; swans and geese, and a variety of wild ducks, loons and divers; many snipe, plovers, sandpipers and their allies; curlew; gulls and terns, of which there are numerous species; skuas and petrels; guillemots and auks, and the puffins. In fact the ornis, as a whole, of Norway is by no means an uninteresting one, notwithstanding the fact that the majority of its representatives have been known and described for so many centuries past. With these facts before us then, it can easily be appreciated that the birds of Norway offer the photographer of such subjects almost as varied a field of bird life as he can find in the United States, and the same is true of their nests and eggs. Again, Norway is especially interesting in her topography and plant life, or flora. That this is so has led many of her bird photographers to include in their pictures more of the surroundings than is usually the case in similar productions taken in this country by American ornithologists. All the photographs illustrating the present article are good examples of this, and, in my opinion, everything else being equal, it gives them an additional value; especially as any one of them will bear enlargement either for lecture purposes or for figures.

For photography, many of the water birds offer wonderfully attractive subjects, and particularly on the coast north of Stavanger, where

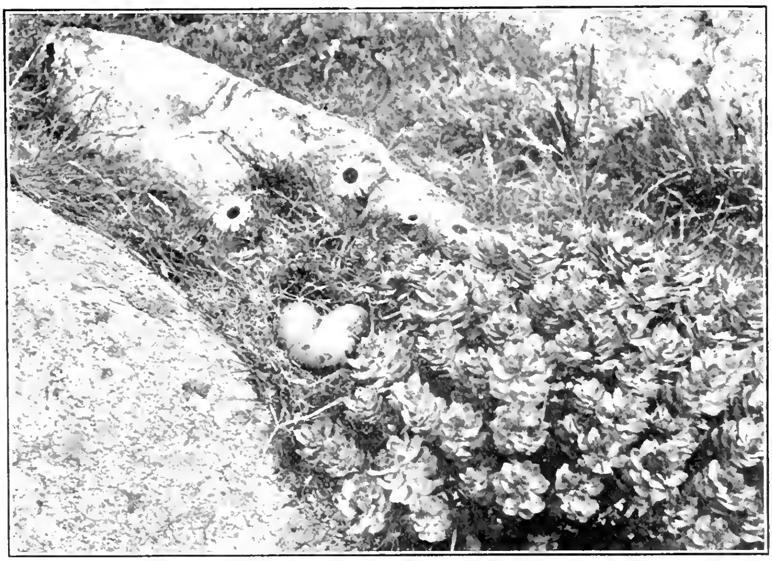


FIG. 1. NEST OF COMMON GULL (*Larus canus*). (Bratvær)

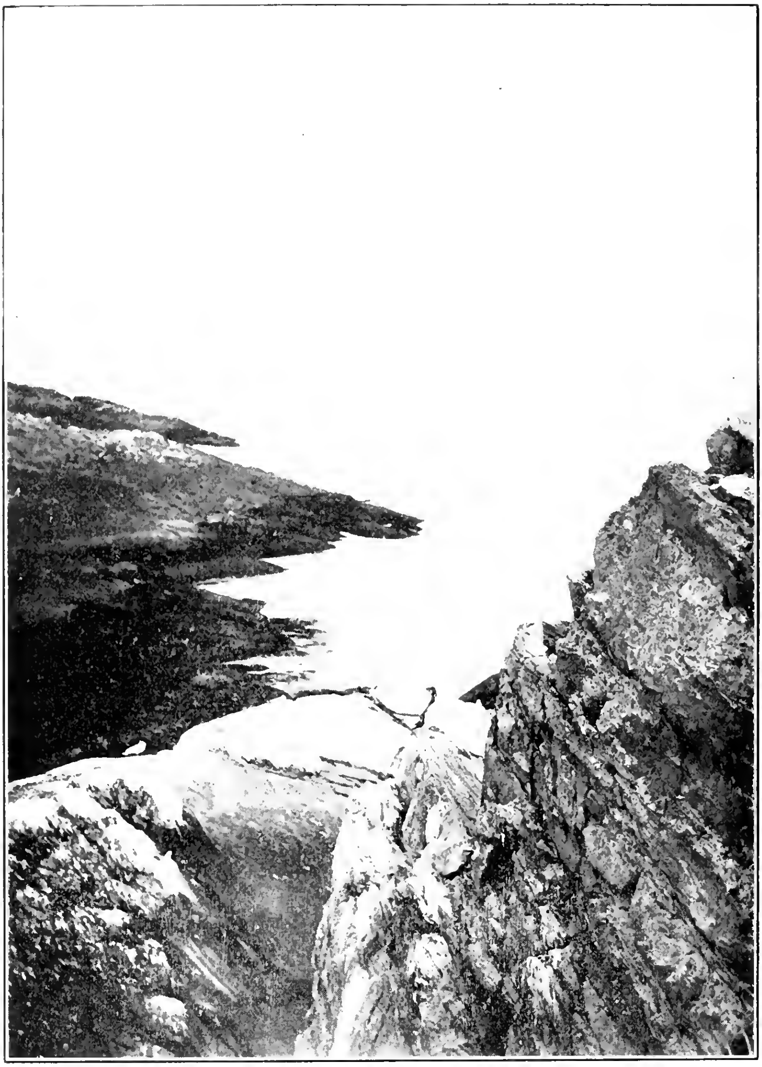


FIG. 5. BIRD ROCKS AT VARLÖ.

auks, gulls and various other kinds of water fowl breed in immense numbers on the high, bold cliffs facing the ocean. Puffins (*Mormon fratercula*) are also found here in myriads, inhabiting the bird-cliffs or 'fugleberge,' and these preserves are protected by their owners, who derive considerable profit from them.

In another locality off Stavanger, we find the small island of Rott. Here many birds breed, and in far more accessible locations, and often on the sandy and rocky stretches near the ocean. Cormorants breed here in numbers (*Phalacrocorax graculus*); at least two species of gulls (*Larus canus and Larus fuscus*)—the common gull and the lesser black-backed. (See Fig. 4.) The European oyster-catcher is also found breeding on this island, a species closely resembling our own American form. An interesting photograph of the former, and the three beautiful eggs it lays among the stones and pebbles on the beach, is shown in Fig. 1 and 2. A large colony of the common gull were breeding in the near neighborhood. The inhabitants of this island of Rott belong to an ignorant class of coast people, who make profit on anything that mammal, bird or fish may bring them, subsisting themselves on the same products. They kill and eat both the cormorants and the gulls, and have a habit when the birds are first hatched of clipping the outer feathers of the wings, and consequently the birds are never able to fly. Then after they are full grown they

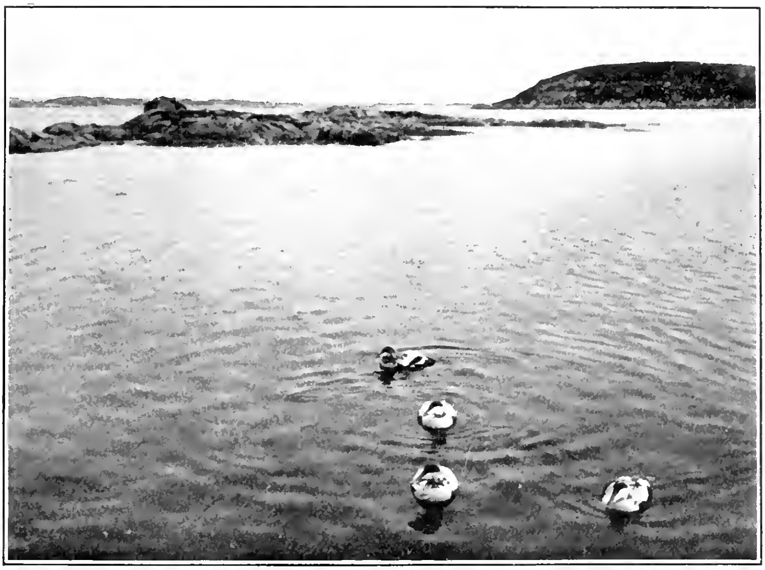


FIG. 6. EIDER DUCKS. (Bratvær.)

are easily caught and killed in numbers, being immediately salted down for winter food. With respect to the cormorants, the young are decapitated in their nests, as soon as they are old enough, and put to similar uses. Nowhere else in all Norway does this custom prevail. When Professor Collett visited this island of Rott, he ascertained that the inhabitants did not use the razorbill auks for food, and that these birds were marvelously tame, so much so that when he undertook to photograph them, one of the legs of his tripod was in touch with the tail of one of the birds in the immediate foreground when he secured the picture reproduced in Fig. 3. He was also in plain view at the time.

Another interesting picture of an auk (*Alca torda*) is shown in Fig. 5. This was secured at Vardö, in northern Norway. From this

FIG. 7. TENGMALM'S OWL IN ITS NATIVE HAUNTS.

view we can look seaward toward Spitzbergen, and directly in the direction of the North Pole. The auk is seen standing on the rocks in the middle distance; and also further to the left there is a gull.

Some charming photographs of wild ducks have been taken down at Bratvar, where the celebrated fisheries for torsk and herring are. There occur the famous eider ducks (*Someteria mollisima*), which yield the precious eiderdown, so extensively used as a lining for fashionable winter garments. These ducks heavily line their nests with this down, and its collecting is an industry of no little commercial importance. We also have several species of eider ducks in our own avifauna, and in some parts of the world they have been domesticated. Bratvær (*Smölen*) is just outside of Christiansund, a place situated about midway on the coast of Norway.

Although wild specimens, the four male eiders seen swimming in Fig. 6 were so tame that they were coaxed ashore by having food thrown to them. The three spotted individuals in the picture are birds that are in the process of assuming their summer plumage. We have in this illustration an excellent view of the character of the off-lying rocky islands of this region.

In Norway they do not have nearly the number of species of owls that we have in our avifauna here in the United States, but still they have a few interesting different kinds. As a matter of fact, in the former country only about six or seven species occur, while over forty species and subspecies are known to inhabit the latter. Of these one or two are common to both countries, as, for example, the well-known snowy owl, and others. Again the little Tengmalm's owl is a common form in Norway, and we have a subspecific race of it in our avifauna. While rambling through the pine forests of Ringebo, Gudbrandsdalen, Professor Collett frequently met with Tengmalm's owl and obtained photographs of it. One of the most interesting captured of this kind is shown in Fig. 7.

As every sportsman who has hunted through Norway knows, the most numerous and important game bird is the ptarmigan, there designated as the 'rype.' It occurs in great numbers, not only on the islands off the coast, but also in similar regions inland, that is, in the fjelds region, or the birch and willow belts. Moreover, they are extremely plentiful on the treeless island of Smölen, in the bailiwick of Nordmöre, where recently they have been hunted with dogs, though the former practise was to snare them.

Several species and subspecies of ptarmigan occur in different parts of the United States, principally in the northwest and through Alaska, while in Norway the common form prevails—the *Lagopus lagopus* of science. A beautiful picture of the nest of one of the latter is shown in Fig. 8. The site selected by the bird was among the roots of several gnarled and twisted birch trees, which are peculiar to the upper birch forests where alone they occur, for, strange to relate, these same birch trees grow quite straight and perpendicular in the lowlands, constituting a difference I am at present unable to explain. It will be noticed that there are but seven eggs in this nest, while a ptarmigan may lay at least three more to complete the clutch. Ptarmigans are white in winter, but tawny and mottled in their summer plumage, so when the female is sitting upon her nest she harmonizes very well with her surroundings. Professor Collett photographed this specimen while she was sitting, but he tells me the picture is not a success.

FIG. 8. NEST OF PTARMIGAN. (Orkedal.)

American ornithologists have frequently obtained fine photographs of a number of our game birds while they were sitting upon their eggs, as grouse, quail and woodcock, and several of these I have published in former articles.

THE PROGRESS OF SCIENCE

THE NIAGARA PROBLEM UNDER LEGISLATION.

THE whirlwind of public expression in regard to diversion of Niagara waters, which has swept through the daily and periodical press, probably constitutes the most notable outburst of recent times over an essentially sentimental proposition. Making allowance for easy extravagances of statement natural to semisensational news articles, the serious elements in the problem have been agitated with so much force and with such preponderance of protests against further encroachments that the whole subject has found its way to the tribunals where the people have undoubtedly wished to get it.

By legislation or treaty, or both, the existing situation, which actually seems to menace the perpetuity of Niagara's natural beauties, can undoubtedly be remedied, but it still remains to be seen whether it will be. At the present writing the remedial measures instituted and in progress at Washington and Albany have created a situation from which the public may, at least, expect some salutary results, but which does not yet justify the rather noisy claims of various civic organizations that they have 'saved Niagara.'

The president in his last message to congress urged legislation and suggested treaty relations with Great Britain to the desired end. Governor Higgins in his annual message earnestly pressed the situation upon the New York legislature. President Roosevelt intimated that if New York could not take care of her rights in Niagara she might cede them to the federal government, but New York has not been inclined to entertain this proposition. Early in the present session of congress Senator Platt introduced a concurrent resolution authorizing the president to invite the cooperation of Great Britain in the appointment of an international commission which should undertake to make recommendations as to the solution of the problem and to appoint the American members thereof. The progress of this resolution, reported by Senator Burton out of the committee on foreign relations, was obstructed by the objection of Senator Teller, who thought that inasmuch as it was essentially a New York matter it must take its allotted place on the calendar, to be reached at some indefinite period in the future. It is understood that in the meanwhile the president had referred the matter of possible treaty relations to the secretary of state, but, if the press reports are correct, the efforts made by this official through the usual diplomatic channels have not yet borne fruit.

Meanwhile the international waterways commission, authorized a few years ago by the secretary of war to consider all problems arising in regard to the control of the boundary waters between the United States and Canada, after specially investigating the conditions during protracted hearings held at Niagara Falls last summer, has made an *ex parte* report in regard to diversion in the Niagara River, that is, a report adopted only by the American section of the commission. This is very strongly condemnatory of the existing and impending situation, and forcibly urges immediate legislation by congress to limit abstraction, if the beauty of the falls is to be preserved. This report calls attention to the fact, elicited by their inquiry, that the present authorized diversion from the Niagara River is 60,000 cubic feet per second, 26,700 to be taken from the American side and 34,200 from the Canadian; that this amount is 27 per cent. of the average discharge and 33 per cent. of the low water discharge of the entire river. It recommends as propositions for legislation by congress that the secretary of war be authorized to grant permits for the diversion (from the American side, of course) of a total not to exceed 28,000 cubic feet per second, this to include not only the power companies but the Erie, Welland and Chicago Drainage Canals. This prohibition is to remain permanent if after two years the Canadian government shall have enacted legislation prohibiting diversion of water pertaining and tributary to the Niagara River in excess of 36,000 cubic feet per second. Press reports indicate that the Canadian section of this commission, in making return to their government, dissent from the attitude of the American section, insisting that the most apparent damage to the falls must necessarily result from American diversion which affects the American side only. This attitude is undoubtedly just, and it is to be seriously questioned if the American section of this commission has given full weight to the fact that diversion of 28,000 cubic feet per second will much more seriously damage the flow of water through the American channel than the abstraction of 36,000 from the other side will affect the Canadian channel.

In the New York legislature action was begun by the introduction of a bill repealing four of the eight outstanding charters for power companies. As these four charters were already dead, the bill passed the senate. This was followed by another senate bill, introduced by the disinterested author of the former, restricting the consumption of water by the four remaining American companies to a maximum of 17,200 cubic feet per second each, or a total of 68,800 cubic feet per second, an amount more than the entire volume of water flowing through the American channel. The public is now too well informed to welcome just this brand of salvation for the falls, and the author of this bill deliberately killed it, saying that he was 'tired of trying to save the falls and could find no sentiment in favor of saving them.'

In the assembly Mr. Cox has introduced a concurrent resolution looking to a referendum for a constitutional amendment to prevent abstraction beyond that already chartered, and Mr. Foelker a bill so worded as to prohibit all American companies and all foreign companies doing business in this state to take more water than is actually being taken at the time of the passage of the act and instituting heavy penalties for violations of these provisions. This is the most radical measure that has anywhere appeared on behalf of the conservation of the falls and is probably the only measure that could actually effect a cure of the present menace to the American cataract. It is demonstrable and already demonstrated, that the full chartered consumption of waters by the American companies will dismantle the American falls, but the influence of these companies is far reaching, and in a public hearing on the two assembly bills mentioned it was decided to amend the Foelker bill so as to leave the companies their charter rights with penalties for transgression of these, and in this form, with the real vital clause extracted, this bill and also the Cox resolution have been reported and advanced. There never has been the slightest probability that any of the power companies would exceed their chartered rights of diversion. Indeed the entire contention has been that it is this chartered right which endangers the falls, and it is the recognition of this fact that constitutes the very meat of the recommendation by the international waterways commission. It does not seem, therefore, that the Foelker bill, should it become a law, will help the situation. Of more practical merit are the six bills, also introduced by Mr. Foelker, repealing the six outstanding charters, four of which are the already dead ones, killed again by the senate bill above referred to, and two the very perniciously quiescent companies, one of which is known to be controlled by a large railroad corporation. It remains to be seen whether these six repeal bills can get through the senate. So far then as the pending legislation at Albany is concerned, it will have little effect on the people's hope for Niagara whether the Foelker restriction bill wins out or fails, but it will be a most important step forward if the six Foelker repeal bills should succeed in reaching the governor.

THE REPORT OF THE PRESIDENT OF HARVARD UNIVERSITY.

The annual reports of President Eliot form a series of educational documents of great and permanent interest, by no means confined to the great university over which he presides. The current report states that the principal event of the year was the raising by general subscription of the 'teachers' endowment fund,' amounting to \$2,300,000, for the increase of salaries in Harvard College. This was locally necessary, as the university was in danger of losing its men to other institutions; it is also of general academic interest. The average salary of the 57 professors in Harvard College was \$3,980, and only 13 received as much as \$5,000. The maximum salary has now been increased to \$5,500 to be paid to all after a long enough period of service. The average salary of 38 assistant professors was \$2,130, and of 88 instructors \$990. These salaries have also been increased. The largest ordinary salaries at Columbia are \$5,000, at Yale \$3,750 and at Pennsylvania \$3,500. It appears to be most unfortunate that while our leading universities have spent vast sums for grounds and buildings, the salaries have remained stationary or have even decreased. The academic career should be made attractive by freedom, security and congenial work rather than by large salaries, but the salaries should be as large as those received for equal performance in other professions. Harvard has once again led the way in an important educational reform.

The report contains an account of the failure to form a merger with the Massachusetts Institute of Technology. The reason given is the decision of the supreme court forbidding the sale of the present site of the institute. This is technically correct, but the value of this land is really a small matter. It could have been readily transferred to the city for park or other public purposes without cost to the institute if the removal and the combination with Harvard had met with general approval. The fact is that the plan failed because the faculties and alumni of the two institutions opposed the union that was favored by the presidents and the corporations. We have here an interesting question of ultimate academic control, which President Eliot fails to discuss or even to notice.

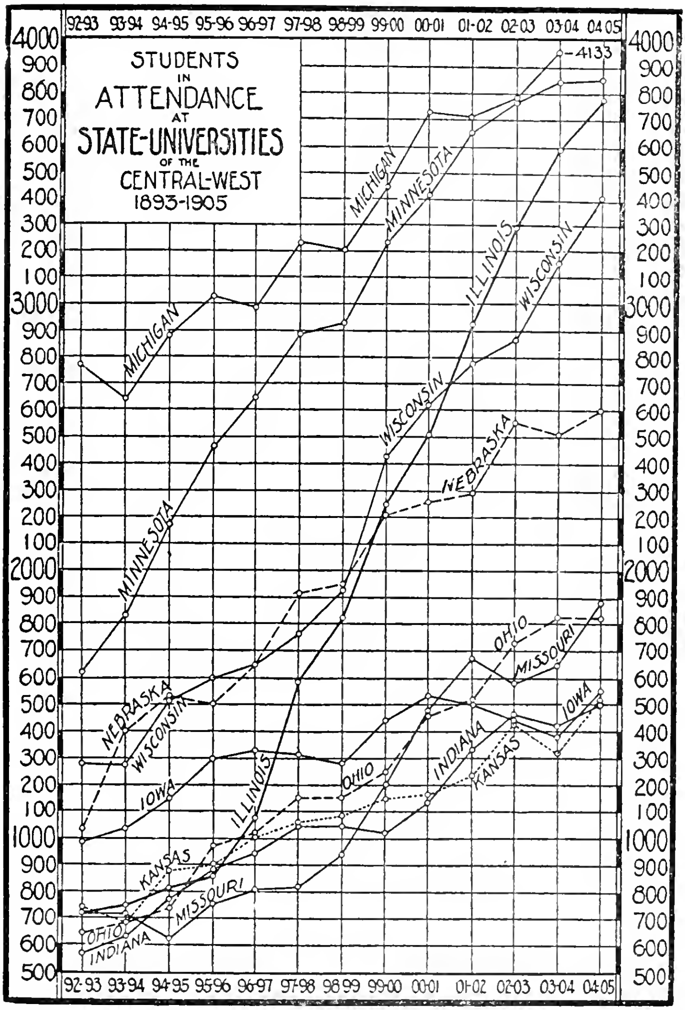
Some elaborate statistics are given in the report in regard to students who have taken different kinds of college degrees during the past fifteen years at fourteen institutions of different type. These show that the old classical course has completely lost its predominance. The A.B. degree is now given at Harvard without Latin, though a classical language is still required at entrance. In many institutions, for example since 1901 at Michigan and Cornell, and since 1904 at Wisconsin, the A.B. is given without regard to the kind of entrance examination, and the number of degrees of this kind has greatly increased. Thus Wisconsin gave only 21 A.B.'s in 1903, as compared with 194 in 1905. Where two or more courses are maintained, one retaining more or less of the classics and the others without, the classical course tends relatively to lose ground. Thus in 1891 there were at Yale 832 students

THE HARVARD CORPORATION.

in the academic department and 374 in the Sheffield Scientific School; whereas last year the numbers were 1,275 and 875. In Princeton the similar figures are 504 and 155 in 1890 and 838 and 558 in 1905. President Eliot appears to favor giving only the A.B. degree for undergraduate study, but Harvard has this year established a bachelor of science degree in the college.

Of the many other interesting topics treated in the report, we can only mention the severe arraignment of football. No one objects to seeing our 'young barbarians all at play,' but under existing conditions of professionalism and commercialism, President Eliot does not perhaps word it too strongly when he says: "It is clearly the duty of the colleges, which have permitted these monstrous evils to grow up and to become intense, to purge themselves of such immoralities, and to do what they can to help the secondary schools to purge themselves also."

Harvard University has a form of government different from that of other American universities. Since 1650 the corporation has consisted of the president, the treasurer and five fellows, who are in certain respects responsible to the board of overseers, which is now elected by graduates of the college. By the courtesy of the *Harvard Graduates Magazine*, we are able to reproduce here portraits of the present members of the corporation. The body is so small that the members take an active interest in the welfare of the university; they have always been men of distinction in the community.



THE GROWTH OF THE STATE UNIVERSITIES OF THE CENTRAL WEST.

Harvard was once under the control of the State of Massachusetts; now there is agitation in favor of taxing the university. This change in attitude may not injure the university, but it is unfortunate for the people. In the central and western states the universities are supported with increasing liberality. In spite of the vast endowments of Chicago and Stanford, there is reason to believe that the state universities of Illinois and California will not be allowed to fall behind. The extraordinary growth of the state universities of the central west is shown on the accompanying chart, which was used in connection with the inauguration of President James, at the University of Illinois. The sevenfold increase in the number of students at that university in twelve years is most remarkable, but it is nearly paralleled by Minnesota and Wisconsin.

The present registration in the largest eastern private foundations is as follows: Harvard, 5,283; Columbia, 4,755; Cornell, 3,871; Yale, 3,477. In the four leading state universities of the middle west it is: Michigan, 4,521; Minnesota, 3,940; Illinois, 3,635; Wisconsin, 3,083. There are 17,386 students in the one group and 15,179, in the other. The increase last year in the eastern institutions was 320, in the western 554. The future growth of these universities will be a matter of interest. But it must be remembered that the greatness of a university is not measured by its size. The Johns Hopkins with 688 students has on its faculty thirty of our leading men of science; Illinois with 3,635 students has only six.

THE TOMB OF JAMES SMITHSON.

One of the last services of the late Professor Langley, secretary of the Smithsonian Institution, was his share in the removal of the body of Smithson from Genoa to Washington, where it now lies in a mortuary chapel at the north end of the Smithsonian Institution. Smithson died at Genoa on June 27, 1829, and was buried in the little English cemetery on the heights of San Benigno. There was originally no reference on his tomb to his foundation of the Smithsonian Institution, but a tablet was erected some ten years ago by the regents, who also undertook the care of the grave. But it became necessary to move the cemetery, and Dr. A. Graham Bell proposed to bring the body of Smithson to America to rest in the great institution of which he was the founder. Dr. Bell offered to defray the expenses, but was commissioned by the regents to undertake this duty on their behalf. He immediately proceeded to Genoa, where he arrived on Christmas Day of 1903. With the cooperation of our consul, Dr. Bell was permitted to exhume the body and bring it with him to the United States, where it was received with naval and military honors. On March 6, 1905, the remains were replaced in the original tomb in the chapel of the Smithsonian Institution, where they will rest until congress makes provision for their interment.

The story of Smithson's life is this: The illegitimate son of the first Duke of Northumberland, he was a gentleman commoner at Pembroke College, Oxford, and was elected fellow of the Royal Society in 1786 at the age of twenty-one. He made contributions to chemistry of some importance, but suffered from ill health and discouragement. He lived on the continent, and was at one time at least a Jacobinite, regarding a king as a 'contemptible encumbrance.' He left his fortune to his nephew with the provision that if he died without heirs it should go 'to the United States of America, to found at Washington under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men.' The United

THE TOMB OF JAMES SMITHSON IN THE SMITHSONIAN INSTITUTION.

States accepted the bequest, which amounted to $550,000, and after long discussion within and without congress the institution was established, which has so completely carried out the wishes of its founder.

SCIENTIFIC ITEMS.

WE regret to record the death of Nathanial Southgate Shaler, professor of geology at Harvard University; of James Mills Peirce, Perkins professor of astronomy and mathematics at Harvard University, and of Robert Ogden Doremus, emeritus professor of chemistry at the College of the City of New York.

PROFESSOR E. C. PICKERING, director of the Harvard College Observatory, has been elected a corresponding member of the Berlin Academy of Sciences.—Dr. Henry F. Osborn, professor of zoology at Columbia University, and curator of paleontology at the American Museum of Natural History, has been elected a foreign member of the Linnean Society of London.—Dr. William Osler, regius professor of medicine at Oxford University, has been elected a member of the Athenæum Club, under the provisions which empower the annual election of nine persons 'of distinguished eminence in science, literature, the arts, or for public services.'

FATHER J. G. HAGEN, S.J., professor of astronomy in Georgetown University, and director of the observatory, has been offered the directorship of the Vatican Observatory.—Mr. Arthur Eddington, B.A., B.Sc. (Manchester), of Trinity College, Cambridge, senior wrangler in 1904, has been appointed chief assistant in the Royal Observatory, Greenwich.

THE American Philosophical Society is holding as we go to press a meeting in memory of the two-hundredth anniversary of the birth of Benjamin Franklin, its founder. In addition to the scientific program, which includes papers by Sir George Darwin and Professor Hugo de Vries, there are a number of special addresses. Professor Edward L. Nichols, of Cornell University, will speak on 'Franklin's Researches in Electricity' and Professor E. Rutherford, of McGill University, on 'Modern Theories of Electricity and their Relation to the Franklinian Theory.' Special addresses in commemoration of Franklin will be made by Dr. Horace Howard Furness, President Charles W. Eliot and the Honorable J. H. Choate, and the Honorable Elihu Root will, in accordance with the act of congress, present the Franklin medal to the Republic of France.

The Clarke School for the Deaf at Northampton, Mass., will receive an annual income of $1,500 to enlarge the training school facilities from the fund recently received by the Association for Teaching Speech to the Deaf, given to them by Dr. A. Graham Bell. Dr. Bell became heir to about $75,000 from the estate of his father, Dr. Melville Bell, the inventor of the system of visible speech, and he made over this sum to the association. His condition was that it should be used as a permanent memorial of his father's connection with the subject, the homestead in Georgetown, D. C., to become the office of the association, for printing, etc., and about half the property to have its income devoted to the training of teachers of the oral method.

For the best essay on 'Moral Training in Public Schools' a prize of five hundred dollars is offered, and for the second best, three hundred dollars. The conditions are: (1) Length of essay to be not less than 6,000 nor more than 12,000 words; (2) each essay must be submitted typewritten; (3) all essays must be in the hands of the committee not later than June 1, 1906. These prizes are offered by a citizen of California who desires his name withheld. He has appointed Rev. Chas. R. Brown, of Oakland, California; President David Starr Jordan, of Stanford University, and Professor F. B. Dresslar, of the University of California, Berkeley, 'trustees of the fund and sole judges of the merits of the essays submitted." The two prize essays shall become the property of the trustees, to be by them 'published and circulated as widely as possible' from the fund at their disposal 'within the limits of the United States.' Any essay not awarded a prize will be returned to the writer upon request, accompanied by postage.

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CONCERNING VARIATIONS IN ANIMALS AND PLANTS

By PRESIDENT DAVID STARR JORDAN,

STANFORD UNIVERSITY

WITHIN any given species of animals or plants as occurring in nature, variations of many sorts may appear. No one individual is the exact image of another, either in structure or in function. In theory, at least, no one cell is exactly like another, no one chromosome the exact duplicate of a mother or a sister chromosome. Moreover, no one group or aggregation of individuals is exactly like another, if separated from it by time or space. In the classification of variations we may naturally divide them into individual variations and collective variations. Collective variations are produced by the extension of certain types of individual variations from generation to generation. These form the basis of new species, as gaps are produced within the series by isolation or by the death of intermediate forms.

Individual variations are again sharply divided into those which are inborn or blastogenetic, and those which are acquired or ontogenetic, produced by the direct influence of environment or by the reaction of the organism from external conditions.

The inborn variations arising from differences in the original germ cells, male, female or both, or from results of their combination or amphimixis, may be again subdivided as fluctuations, saltations, monstrosities and hybridizations. So far as we know it is alone from inborn variations, as perpetuated by heredity, as sifted by natural selection and as protected by bionomic isolation, that collective variations, nascent species and new species originate.

Fluctuations

The small differences, numerous but slight, and never wanting, which distinguish one individual from another of the same species have been termed fluctuations. These occur in every individual, in every organ and practically in every direction. They are traceable, on the one hand, to differences in the germ cell, and in the process of mitosis or cleavage to which it is subject, and, on the other, to the fact of amphimixis, or double parentage, universal in the higher animals and plants. These fluctuations are hereditary, but their existence is easily obscured by the fact that the slight variations in the one parent rarely coincide with those of the other. In the progress of a species, individual fluctuations tend to neutralize one another.

It is, however, certain that fluctuations can be rapidly intensified and rendered stable by the process of selection, either natural or artificial. While it is probably true that few species originate by the process of selection alone, it is almost certain that it is possible for selection alone to produce groups equivalent to those we call species. There is apparently no limit to what man can do by the persistent preservation of favorable or desirable fluctuations. The same results must occur in nature when the same process takes place if it ever does take place. A slight advantage on the side of any special fluctuation will change the average variation in that direction and in time make the character permanent.

One of the first noteworthy studies of fluctuations as distinguished from climatic, environmental and geographic variations was that made by Dr. J. A. Allen in his paper on the 'Mammals and Winter Birds of East Florida,' published in 1871. In this paper Dr. Allen gives measurements of many specimens of various species of common birds, with a view to ascertaining the normal rate of variation. In this regard, the study of birds is much more instructive than that of most groups, because a bird of any species rapidly reaches a natural stature. It is affected in its growth by environment or food conditions much less than the members of most other groups. The well-fed bird reaches its normal stature, the ill-fed or injured bird dies, and the bird changes little with growth, its adult condition being once attained. Among adult male birds, characters due to accidents of condition are reduced to the minimum.

Dr. Allen finds that each part is subject to an ordinary variation of from 15 to 20 per cent. in its measurements, this in specimens of the same age and sex; at the same time each part varies independently of the others, even each feather of the wing and tail. Each toe may vary for itself, and the bill and the claws are subject to the same deviations from the normal. Color variations are equally well marked, and the variations within the species as represented in a single locality are often as great as those which actually distinguish species. In birds with streaks or spots, these markings vary in size, form and number, each individual having its own traits, which persist through the seasonal changes of plumage. It is part of the art of the faunal naturalist or systematist to determine which of these characters represent individual variations and which are associated with distinctness of species.

In general, the conditions of a species may be compared to a target filled with marks of shot. The bull's-eye represents the normal position of the shot, but variations in every direction occur. As one goes away from the bull's-eye the shot marks are fewer in number, but some of them may fall at a considerable distance from the center or average. Sometimes the majority may lie on one side of the center. This would indicate a continuous influence acting in one direction, as the wind affecting the direction of the bullets. Among animals a similar deviation from the usual may indicate a climatic effect, or the effect of natural selection under different conditions. That either of these influences may cause a mass variation within a group admits of no shadow of doubt. Nor is there any doubt that fluctuations within the species may and do constantly go as far as to equal the usual distinction between one species and another. The sole test of a species is in the relative permanence of its group of characters, not in the extent of its deviations from some other group. And in almost every case where the actual origin or cause of separation of one species from the next can be traced, it is found to have a geographic factor. Doubtless favorable fluctuations could be added together until those possessing them should be segregated from the mass about them, but we have no certain knowledge of any such cases. Doubtless individual fluctuations (saltations) could be so extreme as at once to segregate their possessor from all its neighbors. Doubtless new species might and perhaps do originate in that way, but out of the hundreds of thousands of species studied in nature, not one is certainly known to have had such an origin. But let any group of individuals be separated from their fellows, no matter how, in time the individuals remaining will come to an equilibrium with a different center of variation or a different arrangement of average characters from those possessed by the parent stock. The characters of any species represent the equilibrium or result attained by the forces of heredity and the operations of local natural selection.

We may again divide the traits of the fluctuations or minor variations of the individual into three classes, those useful, those indifferent and those harmful. A useful variation may cause the survival of the individual; a harmful variation may cause its destruction.

In considering the traits of a species, these classes of characters are reduced to two. Adaptive characters—those associated with the well-being of the individual—and non-adaptive, or indifferent characters—those which have no evident relation to utility. Characters positively harmful are always eliminated so far as the species is concerned.

In the actual work of the description of species, we recognize at once that adaptive characters are older than the non-adaptive characters. This is true, even though the adaptive character itself be a relatively recent one. The flying-fishes flew before the group was split up into thirty species. Yet the enlargement of the fins of these fishes is one of the latest products in fish evolution.

The species of Hawaiian birds of the family of Drepanidæ are among the latest results of bird development. Yet these birds were divided into genera characterized by the form of the bill, each type of bill being adapted to a special purpose long before the present actual species were themselves differentiated.

All the orioles build hanging nests, and all are adapted alike in structure and instinct to their mode of life. All the sparrows and finches have bills fitted for cracking seeds. And these features of adaptation preceded the subdivision of orioles or sparrows into their present genera and species. In general, the traits by which we distinguish species are non-adaptive characters, while the features of adaptation are most distinctly traceable in structures common to many species, the characters of genera or of families in zoology.

But in this we find certain paradoxes. In studying the characters of members of a zoological family, we find that the most distinctly adaptive characters are relatively recent. It is a truism that physiological characters have a lower systematic value than characters not related to the character of life processes. The traits that fit animals for a special kind of food or for a special kind of topography are recognized as of low value in taxonomy. In other words, special adaptations are of relatively recent origin. General adaptations are older than special adaptations. Hence they have a higher value in classification. A flying-fish is fitted to swim in the water before it is adapted to leap in the air. But all general adaptations began some time as special ones. General adaptations have become so ingrained in the life of animals that they are, in a sense, invisible to the systematist. He passes them by as matters of course, directing his attention to special adaptations or to special peculiarities which seem to be devoid of utility. The ancient adaptations are not even considered as adaptations at all, when we say that adaptive or physiological characters have a low value in classification. And it is from this fact that the seeming paradox arises.

Again the adaptive character in the race or species may appear to be of very recent origin. The Southdown sheep of England had tawny faces before they acquired their present traits of wool or mutton. The explanation of such cases is this: an adaptation is never finished, a more rigid selection may at any time enforce a more rigid adaptation. Natural selection acts as a constant influence. It may be varied or intensified under new circumstances, as when it is directed by the will of man, when it becomes artificial selection. And under the influence of artificial selection a non-adaptive or indifferent character becomes adaptive or selective. Among those animals or plants which submit readily to domestication almost any natural species, distinguished by non-adaptive characters, could be reproduced with all its traits by a process of carefully controlled selective breeding.

Saltations[1]

It has long been known that individual fluctuations of an extreme degree sometimes occur, and that these may be to a degree persistent in heredity. Of such nature was the Ancon sheep, the iceberg blackberry and numerous other races or forms known in the domestication of animals or the cultivation of plants. The generally normal structure of such individuals distinguishes them from monstrosities, which are usually freaks of development rather than of heredity.

The name 'saltation,' or in recent years 'mutation,' has been applied to extreme fluctuation, the immediate cause of which is unknown. The experiments of Dr. Hugo de Vries on the saltations of the descendants of an American form of evening primrose (*Œnothera lamarckiana*) have recently drawn general attention again to the possibility that saltation has had a large part in the process of formation of species. As to this it may be said that the possible variation within each species is much greater than the range of the individuals which actually survive. The condition of domestication favors the development of extreme variation, because such individuals may be preserved from interbreeding with the mass, and they may survive even if their characters are unfavorable to competition in the struggle for existence. Among plants it is noticed that new soil and new conditions seem to favor large variation in the progeny, although the traits thus produced are rarely if ever hereditary. Cases more or less analogous to those noted by Dr. de Vries are not rare in horticulture. The cross-breeding of variant forms favors the appearance of new forms. Among actual species in a state of nature, there are very few which seem likely to have arisen by a sudden leap or mutation. The past and the future of de Vries's evening primroses are yet to be shown, and it is not at all unlikely that the original *Œnothera lamarckiana* found in a field near Amsterdam was a hybrid stock, a product of the florist, the behavior of its progeny being not unlike that which appears in the progeny of hybrids. The species called by de Vries *Œnothera lamarckiana* is not known in its wild state anywhere in North America, the parent region of the species of evening primrose or *Œnothera*. It is, moreover, known that the seeds of hybrids of an American species, probably *Œnothera biennis*, the common evening primrose, with other

[1] The name saltation has been long used for wide fluctuations without recognizable cause. The more recent name mutation chosen by de Vries has been in use for years for the slow changes appearing in geological time.

American species produced by Mr. Burbank, have been in past years sold in the cities of Germany. In any event, we have as yet no reason to assume that the various mutants of the evening primrose are in any sense comparable to the wild species of the same group now existing in America.

While saltation remains as one of the probable sources of specific difference, its actual relation to the process of species-forming in nature is yet to be proved.

Dr. de Vries's assertion that the process of natural selection is mainly a conflict between saltatory offshoots and not a competition between similar individuals ('intraspecific instead of interspecific competition') is hardly justified by the facts. The real conflict is that of the individuals maintaining life against the pressure of external conditions.

In the struggle for existence, each individual survives which can. The close presence of other similar individuals and that of unlike individuals are alike parts of the environment which each individual that leaves progeny has in some degree succeeded in conquering. This conquest takes place through adaptation to the actual conditions, concession to the actual environment.

It is highly probable that saltations in general are of the same nature as fluctuations, and that they occur in nature far more commonly than has been supposed. Unless in some way protected by isolation, the traits thus developed are likely to be swamped and lost by interbreeding with the mass. But it is conceivable that they are not always thus lost, as a very favorable variation may overwhelm the mass. But it is also clear that isolation of some sort would be usually, if not always, essential to any survival of a group possessing saltatory characters.

Hybridization

In crossing related species, new forms arise, having in part a blend or a mosaic of the characters of the two parent species, in part other traits or characters, the origin of which may not be clearly traced. Usually the second generation shows a great range of variation, often deviating farther in some respects from the average type than was the case with either of the original parents. The progeny of these variants may also vary widely. It has been sought to define the laws governing these variations. When only a few easily recognized characters are concerned, it has been possible to trace a certain regularity, conforming in general to the Mendelian law. But different species differ not in one way, but in a thousand ways. These traits are so interwoven and so variously related, some of them cumulative and some contradictory, that in most cases no law determining which characters shall be dominant in each case and which recessive can be made out. While the

Mendelian law may be of universal application, it is in a few cases only that its facts can be clearly seen.

In heterogeneous hybridization or the crossing of distantly related forms, all sorts of results are reached, according to the nature of the forms in question. In few cases does the progeny become mature, and still more rarely does it prove fertile. If the plans of structure inherited from the two parents do not coalesce with reasonable completeness, nothing comes of the development of the progeny. Thus the strawberry may be readily crossed with the raspberry. The resultant plant grows and blossoms, but the divergent lines of heredity can not agree on the structure of the fruit, and the plant is wholly sterile.

In Mr. Burbank's cross of the European walnut (*Juglans regia*) with the California walnut (*Juglans Californica*), the first generation shows a certain blending of the traits of one species with those of the other. In the next generation appears every conceivable kind of variation in every feature of the plant and in every function of its organs.

Among artificial hybrids of different species a few are fertile and breed true to the parent stock. Among these are the Primus berry, a cross between the blackberry and raspberry, and the Logan berry, a chance cross between a cultivated raspberry and a California blackberry (*Rubus vitifolia*) growing outside a garden fence in Santa Cruz, California.

These two plants might be properly called distinct species, if we were not aware of the circumstances of their actual origin. But hybrids rarely form distinct species in nature. European writers have defined numerous hybrids among the fresh-water Cyprinidæ of the continent of Europe. Nothing of the sort occurs in the same group in America, and the evidence for hybridization needs at least re-examination.

Among American birds we have three notable cases: In the genus *Helminthophaga* (*Helminthophila* Ridgway), a group of American wood warblers, three nominal species have been described, each of which is usually regarded not as a true species, but as a hybrid of two of the common forms. One of these, called *Helminthophaga cincinnatiensis* Langdon, is 'obviously a hybrid' between *Helminthophaga pinus* and *Oporornis formosa*. *Helminthophaga lawrencei* Herrick, known from a few specimens, is perhaps a hybrid of *Helminthophaga pinus* and *H. chrysoptera*. *Helminthophaga leucobronchialis* Brewster, known from some scores of examples from various localities, is probably also a hybrid of the same two species. "It is probable," says Mr. Ridgway, "that both in the case of this form and *H. lawrencei,* that dichromatism, as well as hybridism, enters into the question of their origin. While *H. pinus* apparently exhibits rarely a white and gray phase (instead of olive and green) and *H. chrysoptera* as rarely a yellow and olive green instead of white and gray phase, the two species interbreed to such an extent not only with one another, but each with *H. leucobronchialis* and *H. lawrencei* (the hybrids being fertile *inter se*), that the problem is a very complicated one and therefore most difficult to work out satisfactorily."

Mr. W. E. D. Scott has lately maintained that these forms or species of warblers are not hybrids, but the results of saltations or mutations in the sense in which the word is defined by Dr. de Vries. But this view of the case finds little favor among ornithologists who continue to regard these forms as true hybrids.

In a single genus of marine fishes, the pargo or snapper (*Lutianus*), the types of certain nominal species have been suspected to be hybrids, because they show a perfect blend of the traits of well-known and related species found in the same waters. Of *Lutianus lutianoides*, from Cuba, one specimen is known. It is thought to be a hybrid of *Lutianus apodus* and *Ocyurus chrysurus*. Of *Lutianus brachypterus*, from New Providence, there is one specimen, thought to be a hybrid of *Lutianus griseus* and *Lutianus synagris*. Two specimens of *Lutianus ambiguus* have been found in Cuba. It is thought to be a hybrid of *Lutianus synagris* with *Ocyurus chrysurus*. Nothing is known as to the fertility of any of these forms. The record of such hybrids shows how rare is the occurrence of this phenomenon among fishes.

Along the boundary line of the western distribution of the golden winged flicker (*Colaptes auratus*) of the eastern United States, the species overlaps the range of the red-shafted flicker (*Colaptes cafer*), a species which replaces the first in California and Mexico. Among other differences, the former has the shafts of the wings and tail yellow. The other has these shafts red. But where the species meet individuals occur variously mixed. Some even have the tail red on one side and yellow on the other. These individuals have been recorded as hybrids (*Colaptes auratus hybridus*), and this origin is in fact probable.

In the Sonoran region, along the meeting line of *Colaptes cafer* (*var. collaris*), similar crossing with a Mexican golden woodpecker (*Colaptes chrysoides*) is said to take place.

Hybrids of wild plants sometimes occur, but the cases are rare, and in general it may be doubted whether hybridization has had any appreciable part in the origin of species.

Selection

The individuals possessing any sort of variations, large or small, fluctuation or mutation, are subject to the struggle for existence. This is the test of fitness. To live and to leave progeny means in itself a high degree of adaptation. Every form of struggle, as indicated above, is a struggle with the conditions of life, the competitive features, however, being inevitable accessory conditions. All struggle is in fact intraspecific, that of individuals within the species. When members of related species enter into competition in the same region, the struggle becomes in a degree interspecific, one between the species themselves through their actual representatives. But as there is practically no cooperation among members of the same species, except in the family or band relation of the higher animals, the struggle must be in fact always individual. The struggle against the environment in general is in its essence non-competitive, but in the crowd of animals and plants competition becomes part of the environment. Some seeds, we are told, fell on stony ground, but the plants died because they had no depth of earth. Some fell among thorns, and the thorns grew up and choked them. Still others doubtless perished because they were planted too close together. These three causes of the destruction of the great body of animals and plants, the competition with like forms, that with unlike forms, and the pressure of the environment, are present everywhere with all life in varying degrees, and by it all life is forced into lines of adaptation.

With vital characters, selection preserves those which have no utility by the simple action of heredity. All Southdown sheep have tawny faces, although this trait bears no relation to the short firm wool or to the fat and tender flesh, for which traits the Southdown sheep are bred and valued.

In similar fashion, many indifferent characters are traceable in the various breeds and strains of domesticated animals and cultivated plants. We may presume that similar characters in wild animals and plants have been similarly carried along by inheritance from ancestors possessing them. This phenomenon I have elsewhere called 'the survival of the existing.' The actual traits are reproduced by heredity without regard to any question of fitness.

Dichromatism

The phenomena of dichromatism belong to the category of individual variation. In the vast majority of animals, we have the dimorphism of sex. In the beginning the embryo is sexless. From the beginning, by forces imperfectly understood, its development must be directed in one way or another. It must assume the structures and functions of one or the other sex. With certain insects, a polymorphic condition exists. With bees, the caste of workers or atrophic females exists, together with the type of drone and queen. With some ants, still other types of individuals occur, but the dimorphism of sex, or the polymorphism of the division of labor, rests on influences perhaps not altogether inherent in the structure of the parent cell.

In dichromatism, the individual from the first shows one or another of two color patterns peculiar to the species. The screech owls are some gray, some rusty red, within the same species, even in the same nest.

In the same fashion, gray squirrels and black squirrels belong to the same species. In the same species of globe fish, *Tetraodon nigropunctatus,* some individuals are gray, and some citron yellow. In another species, *Tetraodon setosus,* some are gray, some yellow and some deep blue.

In a West Indian species of bass-like fish, strangely misnamed *Hypoplectrus unicolor,* an extraordinary polychromatism occurs. All the known individuals belonging to one or another of the following color forms which have been called species:

a. Soft dorsal checkered or spotted with pale blue or crossed by blue lines (these occasionally obsolete).

b. Body dusky, the head and belly orange, the top of the head olivaceous; a black spot on each side of caudal peduncle close behind dorsal; black band or spot in front of eye not bordered by blue; cheeks, opercle and breast with vertical lines of metallic blue; dorsal yellowish; pectoral and caudal orange; a black spot in the axil; upper margin of pectoral blue; anal orange with blue border; ventral greenish, its base orange. *Unicolor* (= *Maculiferus*).

bb. Body all violet with 5 or 6 more or less distinct black cross bands, the middle one broadest, covering the space from the fourth to the tenth dorsal spine and meeting its fellow under the belly; the band at the nape broad and saddle-like, bounded by 2 pale cross streaks on nape, opercle and cheeks; snout pale, a pale shade across it; ventrals pale or dark; other fins, except spinous dorsal, mostly pale.

c. Cheek with a blue band before eye and some blue spots before it. *Puella.*

cc. Cheek without blue band; no blue spots on snout; colors duller. *Vitulinus.*

bbb. Body and head yellow anteriorly; body abruptly black posteriorly, the black extending forward to a wavy line reaching from first dorsal spine to vent; a broad dark-blue band in front of eye, bordered by sky blue; fins chiefly orange; ventral and anal bordered by sky blue. *Pinnavarius.*

aa. Soft dorsal plain, without distinct blue lines or spots.

d. Preorbital region with 1 or more dark-blue stripes, bordered by bright sky blue (not fading in spirits).

e. Body yellow anteriorly, black posteriorly, the black extending forward to a line joining the nape and last anal ray; fins orange; a single blue-black stripe or spot in front of eye, ocellated with sky blue; caudal peduncle very dark above. *Guttavarius.*

ee. Body all orange yellow, fins orange; snout and lower jaw blue; 2 blue stripes, each bordered with sky blue, before the eye. *Gummigutta.*

eee. Body saffron yellow, orange posteriorly; snout with blue streaks and some blue dots. *Crocotus.*

dd. Preorbital region without blue stripes.

f. Preorbital region with violet spots; a round black spot on side of caudal peduncle; dorsal light greenish; body light olive green above, reddish below; pectorals pale yellow, the first ray blue; ventrals, anal and caudal light orange. *Aberrans.*

ff. Preorbital region without distinct violet spots.

g. General color blackish, brown or yellowish—not indigo blue.
h. Color brownish, the middle of the front of body yellowish; fins all yellow except the ventral, which are black. *Accensus.*
hh. Color yellowish pink; caudal and pectorals pale; ventrals and anal bright light blue. *Affinis.*
gg. Color of body black with violet shades.
i. Pectoral and caudal fins abruptly bright yellow. *Chlorurus.*
ii. Pectoral and caudal fins violet black like the rest of the body. *Nigricans.*
j. General color deep indigo blue everywhere on body and fins; body with 4 to 6 broad cross bars of darker blue.
k. Cheeks plain, without distinct stripes. *Indigo.*
kk. Cheeks with a dark-blue suborbital band between 2 bands of clear blue. *Bovinus.*

What the significance of this extraordinary condition may be, is entirely unknown, nor do we know the determinant causes of dichromatism. It is sufficient for the purposes of this paper to refer to the fact.

Ontogenetic Variations

A vast range of variations are ontogenetic, or dependent on influences affecting directly the life of the individual. These are not hereditary in the judgment of the present writer, and therefore they are not direct factors in the formation of species. Many investigators take a different view, believing in the direct inheritance of acquired characters, or of the effects of environmental or functional conditions, the familiar tenets of 'Neo-Lamarckism' or progressive heredity.

These ontogenetic variations are, strictly speaking, individual, appearing as collective only when many individuals have been subjected to the same conditions. They may be divided into environmental variations and functional variations, two categories which can not always be clearly separated, as variations due to food conditions partake of the nature of both.

In the epoch-making paper quoted above, and in other publications, Dr. Allen shows that climatic influences affect the averages in measurements and in color among birds. For example, in several species of birds, the total length is greater in specimens from the north, while the bills and toes are actually longer in southern specimens. That this condition is due to the influence of climate on development is shown by the fact that numerous species are affected in the same way. It is noticed also that specimens from the northeast and the northwest of the United States are darker in color than those from the interior, and again that red shades are more common in the arid southwest. Similar effects have been recently shown by a study of species of wasps. They may be produced at will by subjecting the larvæ and pupæ of insects to artificial heat and cold. The butterflies of the glacial regions and those developed in an ice-chest have a pale coloration, and a warm environment deepens the pigment.

It has not been shown that any of these effects are hereditary, or that they constitute a factor in the formation of species, although climatic effects may enter into the process of natural selection. I have before me a series of woodpeckers selected by a student (Mr. Hubert Jenkins), which illustrates at once climatic and other subspecific variation. The collection represents the species known as hairy woodpecker (*Dryobates villosus*). Taking the typical form *villosus,* from the eastern United States, we note that specimens from further south (*auduboni*) are smaller in every way, but otherwise similar. To the northward, in Canada and on the Arctic Sea, the birds are much larger, (*leucomelas*) ten to eleven inches in length instead of eight to nine, while the feet are scarcely if at all enlarged. In all these the space before the eye is black, and the belly is darker in specimens from the region having the most rainfall. In the Bahamas is a form still smaller, seven to eight inches long (*maynardi*), with the space behind the bill white. Further westward, in all woodpeckers of this species, the white spots on the wing coverts, characteristic of the eastern forms, nearly or quite disappear, leaving the feathers plain black. Here again the northernmost forms are largest, *harrisi* of the Californian-Alaskan region being nine to ten inches long, those from California being nearly white below, those from the Vancouver region smoky gray, darkest when the rainfall is greatest. The Mexican form (*jardini*) is seven to eight inches long, but in the moist regions of Central America it too becomes deep smoky brown. Of these traits, those relating to the size of the bird and the smoky coloration of its lower parts may probably be regarded as climatic. Whether a bird born of northern parents would reach its full stature in the south, or whether it would grow up with white belly plumage in a rainy district, are both open to question. The experiment can hardly be tested with woodpeckers, but some other group may offer conditions more favorable to artificial breeding.

On the other hand, the loss in the western birds of the white wing spots characteristic of *villosus* and its subspecies, *leucomelas, auduboni,* and *maynardi,* can have apparently no climatic cause, but is one of the results of the primitive separation of the forms on the two sides of the Rocky Mountains, or more properly of the treeless plains where woodpeckers of this type are not found.

It may be noticed that in the related but much smaller American species known as the downy woodpecker (*Dryobates pubescens*), the eastern forms (*pubescens*) have also the wing coverts profusely spotted with white, while in the western form (*gairdneri*) the wing coverts, as in the western forms of *Dryobates villosus,* are nearly or quite plain black. The ornithologists have not yet agreed on a subdivision of this species into larger northern or smaller southern subspecies, nor have the darker specimens from regions of greater rainfall received distinct names. Similar variations have been noted in the Hudsonian chickadee (*Parus hudsonius*) and in other birds of the northern forests. To what extent the variations seemingly due to direct influence of climate are hereditary has not been ascertained.

While the embryo may be deprived of its normal growth momentum, the effect of unfavorable conditions is spent with a few generations of normal life, and no direct change in the heredity of the race is known to arise from the direct effects of environment.

Food Variations of Silkworms

Elaborate experiments in the effects of the underfeeding of silkworms have been made by Professor Vernon L. Kellogg and Mrs. Ruby Green Smith. The following synopsis of the results is given by Mrs. Smith.

The effects of underfeeding (which have been studied in heredity) upon the immediate generation fed on half the normal supply of food, may be classified as (1) physiological and as (2) those subject to quantitative measurement. They are as follows:

I. Physiological:

1. Larval moltings, pupation and emergence of adult delayed and metamorphosis thereby prolonged.
2. Fertility reduced (as indicated by number of eggs laid, number hatching and number of individuals reaching maturity).
3. Mortality in all stages greater than among normally-fed individuals.

II. Variations from the normal which are subject to quantitative measurements.

1. Reduction in size and weight of all parts in all stages (exemplified statistically and quantitatively by larval widths and lengths, by moth wing expanse, and by larval, pupal and adult weights).
2. Reduction in quantity of silk produced, the cocoons being below normal in dimensions, thickness and weight.
3. Degeneration of wing veins slightly more marked than in normally-fed individuals (economy of material being practised to advantage in these comparatively useless structures).

The results of underfeeding in heredity have been studied in three generations derived from the original underfed great-grandparental stock. The characters which the underfeeding was known to affect were studied in a comparative way in 1904 among numerous lots.

Heredity of underfeeding among silkworms whose make-up may be summarized as follows:

1. Lots accustomed always to years of plenty.
2. Lots in which some one of the four generations experienced famine.
3. Lots in which famine was experienced in two alternate or two successive years.
4. Lots in which famine was experienced in three successive or in one alternate and two successive years.

CONCLUSIONS.

Throughout these lots the conclusions were consistent, and were in brief as follows:

1. The lingering effects of a single generation of underfeeding may be definitely traced to the third generation, although the progeny of the underfed generation be given the optimum amount of food.

2. The power of recovery through generous feeding exhibited by the progeny of individuals subjected to famine is so extensive that three generations of plenty succeeding one generation of famine are sufficient to bring about the complete recovery of the race from the dwarfing consequent upon a generation of famine. Thus individuals of the fourth generation — the great-grandchildren of the starvelings — are the compeers in every respect of individuals of normal ancestral feeding. It is highly probable, but not yet proved, that recovery is possible even after three generations of famine.
3. The effects of famine grow less evident the further removed (in heredity) the individuals are from its occurrence in their ancestral history. Thus, in two lots having but one underfed generation in 4, a lot having the underfed generation 2 or 3 years previous would rank higher in all respects than one whose immediate parents were its only underfed ancestors.
4. A fourth generation on insufficient feeding has not yet been reared successfully in two years' trial. It is highly probable that the race cannot survive more than three generations of poor nourishment.

It will be noticed that the differences between the normally fed individuals and those subjected to famine are not species-making differences, as specific characters go with the Lepidoptera, there being no differences in color or patterns, or shape or venation of wings, or larval or adult ornamentation. If a species or race of silkworms were named on the basis of characters induced by famine, it would be a 'size' and 'season' species—a Lilliputian race of silkworms having a lengthy metamorphosis.

While at first glance these experiments might seem to offer an instance of the *inheritance of acquired characters*, it is, however, apparent that the underfeeding affects the nourishment and full development, not only of visible parts of the body, but also of the germ cells and all internal parts of the body. The germ cells need not be said, therefore, to have been influenced by the acquired somatic characters and to have transmitted them as such, but rather they may be said through their own lessened vitality to have produced progeny with characteristics so parallel to those of the parent soma as to make it appear an authentic case of the inheritance of acquired characters. We have, therefore, a case of transmission of imperfect nutrition, not one of true heredity, a distinction made clear by Weismann. Moreover, if acquired characters are really hereditary, their inheritance should last for more than three generations.

One interesting result of this experiment is that (in so far as silkworm testimony goes) temporary trying conditions do not handicap the race in the long run. It is even conceivable that the ultimate result of famine might be a strengthening of the race (physically speaking), the famine playing the part of a selective agent, preserving only the strong and adaptable.

Ontogenetic Species

Of like nature, but often far greater in degree, are the changes in the individual dependent on differences in food, in nurture or in surroundings generally. In the life of a plant the environmental variations may be so great as apparently to overshadow all the innate characters or peculiarities. With the higher animals the direct effect of environment is proportionately less, and it reaches its minimum among birds and the more specialized insects. Yet no individual of any species is without some traits of variation due entirely to environmental influences. In fact heredity does not repeat the traits of the parent, but merely the tendency to develop similar traits under similar conditions. Change utterly the conditions of growth, and the same heredity will show itself in very different results. Strictly speaking, the characters of a species are not those which appear, but the ability to develop these characters under the conditions surrounding the ancestry of the individual.

But there is no evidence that the direct influence of environment is a factor in the separation of species, except as its results may be acted upon by natural selection. We have no reason to suppose that the environment of one generation determines the heredity of the next. It is true in a broad way that the ill-nourished offspring has weaker or less numerous offspring, but weak or strong, their hereditary traits are those of their actual parent stock.

The features of the 'ontogenetic species' or subspecies, have long been known under the name of 'convergence of characters,' 'parallelism' and 'analogous variation.' An 'ontogenetic species' is a group in which the likeness among the members is due, not to genetic connection, but to the exposure of the individuals to like conditions of development. Hence it should have no recognition in taxonomy, which deals with phylogenetic species and subspecies only. But no species is truly defined when only the usual characters, those developed under usual conditions, are considered. To know the species fully, we should know what qualities individuals may develop under all the varied relations of the environment in which they may be placed.

Ontogenetic species, however, tend to become phylogenetic, in isolation from the rest of their kind, by interbreeding among themselves, and under new conditions of selection. The real characters of the race thus formed may be wholly obscured by the more evident characters due to food conditions or to reaction from the environment. To test the characters, phylogenetic and ontogenetic, and to purge the system of species and subspecies founded on the latter, will be part of the work of the student of species for a long time to come.

Taking concrete illustrations—the Loch Leven trout, *Salmo levenensis,* recently discussed, is distinguished in its native waters by certain obvious characters. These disappear when the eggs are planted in brooks in England or in California, and the species develops as the common English brook trout. But it is conceivable that the obvious or ontogenetic traits of the Loch Leven trout are not the real or phylogenetic distinctions, and that the latter, more subtle, engendered through individual variation, inheritance, selection and isolation, really exist, although they have escaped the attention of ichthyologists.

After the species was planted in Yosemite Park in 1896, it remained for nine years unnoticed. In 1905, individuals sent to me were, so far as I could see, exactly like English brook trout. But it is conceivable that differences in food and water have caused slight ontogenetic distinctions. It is certain that in isolation from all parent stocks they will, in time, develop larger differences, which, after many thousand generations, will be specific or subspecific. At present, these trout are quite unlike the native rainbow trout (*Salmo irideus gilberti*) of the Yosemite. The ontogenetic characters will perhaps approach those of the latter, but the phylogenetic movement may be in quite another direction.

Another ontogenetic species is the little char or trout, *Salvelinus tudes* Cope, from Unalaska. In Captain's Harbor, Unalaska, the Dolly Varden trout, *Salvelinus malma,* swarms in myriads, in fresh and salt water alike, reaching in the sea a weight of six to twelve pounds. A little open brook, which drops into the harbor by an impassable waterfall, contains also an abundance of Dolly Varden trout, mature at six inches and weighing but a few ounces. This is *Salvelinus tudes.* In the harbor the trout are gray with lighter gray spots, and fins scarcely rosy. In the brook, the trout are steel blue, with crimson spots and orange fins, striped with white and black. In all visible phylogenetic characters, the two forms of trout are one species. We have reason to believe that fry from the bay would grow up as dwarfs in the brook, and that the fry from the brook would be gray giants if developed in the sea.

But it is also supposable that in the complete isolation of the brook fishes, with free interbreeding, there would be some sort of phylogenetic bond. There may be a genuine subspecies, *tudes,* characterized not by small size, slender form and bright colors, but by other traits, which no one has found because no one has looked deeply enough.

In no group of vertebrates are the life characters more plastic than among the trout. The birds have traits far more definitely fixed. Yet differences in external conditions must produce certain results. I should not venture to suggest that the dusky woodpeckers or chickadees of the rainy forests of the northeast and northwest are purely ontogenetic species or that they should be erased from the systematic lists. But it will be a great advance in ornithology when we know what they really are and when we understand the real nature of the small-bodied, large-billed, southern races of other species of birds. It would be worth while to know if these are really ontogenetic purely, or if they are phylogenetic through 'progressive heredity,' the inheritance of acquired characters, such as the direct effects of climate or as the reaction from climatic influences. Or again, may there be a real phylogenetic bond through geographical segregation, its evidences obscured by the more conspicuous traits induced by like experiences? Or are there other influences still more subtle involved in the formation of isohumic or isothermic subspecies?

Functional Variations

Functional variations are variations produced in the individual by the use or disuse of organs. They are most marked in the most active organisms, notably in man, in other mammals and in birds. They form a large factor in the development of the individual. The education and training of the individual man produces functional variations, as distinguished from innate peculiarities. But the groups characterized by functional variations are of the nature of 'ontogenetic species.' There is no evidence that the current of heredity is affected by changes of this kind, or that they have any direct effect in the formation of true species. At the most, use or disuse of organs seems to affect species only in an indirect way, as by the preservation of those most disposed to functional activity, and which by such activity have been able to meet better the demands of the environment.

Collective Variations

The preservation of individual variations with their extension to posterity gives rise to racial changes, and these to the larger variations which mark change in species.

Collective variations are chiefly of geographical or geological origin: Changes with space produce geographical species and subspecies. To this category belongs the vast majority of species and subspecies recognized in systematic zoology and botany. It is illustrated by the species of wood warbler (*Dendroica*) mentioned in a previous paper.

Changes with time produce geological mutations. It is a fact unquestionable that a species will change on its own grounds little by little with the lapse of time and the slow alteration of conditions of selection. Nations change, languages change, customs change, nothing is secure against the tooth of time. This is in general true, because with time alteration of environment takes place, events happen, there is an alteration of the stress of life and with this alteration all life may be modified.

That time-mutations in all forms of life do take place is beyond question, and some have regarded these slow changes as the chief agency in the formation of species. But the current of life does not flow in straight lines nor in an even current. Species are torn apart by obstacles, as streams are divided by rocks, and the rapidity of their formation is proportioned to the size of the obstacle and the alternations it produces in the flow of life.

We have some basis for the estimate of the duration of a species. When the great glacial Lake Bonneville occupied the basin of the Great Salt Lake, the same species of fishes and insects were found in all its tributaries. Now that these streams flow separately into a lifeless lake, the same species of fishes occur in them for the most part without alteration. One species of sucker (*Catostomus ardens*) and one chub (*Leuciscus lineatus*) are found unaltered throughout this region and in the Upper Snake River (above Shoshone Falls), into which Lake Bonneville was once drained. Other species are left locally isolated, but in one species only (*Agosia adobe*) a small minnow of the clay bottoms can be shown to have undergone any alteration. But with the tiger beetle (*Cicindelæ*) a large number of species have been produced by isolation.

From the Bay of Panama 374 species of fishes are recorded in the recent monograph of Gilbert and Starks. Of these species, 204 are recorded also from the Gulf of California, while perhaps 50 others are represented in the more northern bay by closely related forms.

Comparing the fish faunas separated by the isthmus, we find the closest relation possible so far as families and genera are concerned. In this respect the resemblance is far closer than that between Panama and Chile, or Panama and Tahiti, or Panama and southern California. On the Atlantic side, similar conditions maintain, although the number of genera and species is far greater (about 1,200 species) in the West Indies than at Panama. This fact accords with the much larger extent of the West Indies, its varied groups of islands isolated by deep channels, and its near connection to the faunas of Brazil and the United States.

But it is also noteworthy that while the families of fishes are almost identical on the two shores of the isthmus of Panama, and the great majority of the genera also, yet the species are almost wholly different.

Taking the enumeration of Gilbert and Starks, we find that out of 374 species, 43 are found apparently unchanged on both sides of the isthmus; 265 are represented on the Atlantic side by closely related species—in most cases the nearest known relative of the Pacific species—while 64 have no near analogue in the Atlantic. Of the last group, some find their nearest relative to the northward or southward along the coast, and still others in the islands of Polynesia.

The almost unanimous opinion of recent students of the isthmus faunas finds the latest expression in the following words of Gilbert and Starks ('The Fishes of Panama Bay,' p. 205):

> The ichthyological evidence is overwhelmingly in favor of a former open communication between the two oceans, which must have become closed at a period sufficiently remote from the present to have permitted the specific differentiation of a very large majority of the forms involved. That this differentiation progressed at widely varying rates in different instances becomes at once apparent. A small minority (43) of the species[2] remain wholly unchanged so far as we have been able to determine that point. A larger number have become distinguished from their representatives of the opposite coast by minute (but not 'trivial') differences, which are wholly constant. From such representative forms we pass by imperceptible gradation to species much more widely separated, whose immediate relation in the past we can not confidently affirm. . . .
>
> It is obvious, however, that the striking resemblances between the two faunas are shown as well by slightly divergent as well as by identical species,

[2] 43, or 11 per cent. of the species found on the Pacific side; about 2.5 of the combined fauna.

and the evidence in favor of interoceanic connection is not weakened by an increase in the one list at the expense of the other. All evidence concurs in fixing the date of that connection at some time prior to the Pleistocene, probably in the early Miocene. When geological data shall be adequate definitely to determine that date, it will give us the best known measure of the rate of evolution in fishes.

Of the 82 families of fishes represented at Panama, all but three (Cerdalidæ, Cirrhitidæ and Nematistiidæ) occur also on the Atlantic side of Central America, while of the 218 genera of the Panama list, no fewer than 170 are common to both oceans. The well-developed families, Centropomidæ and Dactyloscopidæ, are peculiar to the two tropical faunas now separated by the Isthmus of Panama. It might be added that the families of Nematestudæ (one species) and Cerdalidæ (three species) are confined to the Panama region, while the Cirrhitidæ (one species) belongs to a group characteristic of the islands of Polynesia.

From this discussion, it is probable that even in isolation some species change very slowly, that with similar conditions the changes within isolated groups of a species may be parallel, and that the specific changes in different groups may progress with very different degrees of velocity. Natural selection apparently furnishes the motive power of change, but the initiative comes from variation and heredity, and its direction and final results depend on a multitude of conditions and circumstances of environment which are largely geographical, topographical or climatic in their nature.

Topographical Segregation

Topographical segregation may bring about the separation of subspecies or species in precisely the same manner as other methods of geographical isolation. An example is that of the deep-water trout of Lake Tahoe, *Salmo henshawi tahoënsis*. The ordinary Tahoe trout, *Salmo henshawi,* lives in the shallow parts of the lake, spawning in the streams. This form, larger in size, more robust in form and less spotted in color, lives in the depths of the lake, spawning near the shore. The difference between the two is not great, but is perhaps sufficient to justify the subspecific name (*tahoënsis*). The two are considered as different species by anglers.

A more strongly marked case, probably of earlier origin, is seen in several West Indian species of grouper or sea bass, belonging to the genus *Mycteroperca*. In these species, the shore forms have an olive-green color, while others, essentially similar, in deep water are crimson or scarlet. Thus *Mycteroperca venenosa,* the yellow-fin grouper, has a scarlet cognate form, *Mycteroperca venenosa apua, Mycteroperca tigris,* likewise green in shallow water, has its deep water representative in *M. tigris camelopardalis*. The same condition holds with *Mycteroperca olfax* of the Galapagos and its cognate *M. olfax ruberrima*. In another species of this type, the Guatívere, *Cephalopholis fulvus* of the West Indies, the shore form is dark olive, (*C. fulvus punctatus*), that found in deeper water is crimson (*C. fulvus ruber*), while in still deeper water is a golden-yellow form, the original *Cephalopholis fulvus*. Similar relation of olive and red forms, or of black and yellow types, has been noticed in other groups of fishes.

In similar fashion, it is claimed that within the species lines of segregation may be set up on a physiological basis those of a certain type not breeding freely with those of other types. This theory is largely hypothetical. It is conceivably true under certain circumstances, but there is little evidence that any particular species has originated in that way.

It is beyond question that differences greater than those ordinarily separating distinct species may be produced by continuous conscious or unconscious selection on the part of man. To what extent these breeds would retain their characters under the leveling processes of nature, it is impossible to say in any particular case. On the other hand, in the nature of things, all of them are of very much more recent origin than competing species in nature. While it may be that no wild species has originated from human selection, it is true, on the other hand, that the races thus produced are the same in essence as the subspecies and species produced in nature. The same forces are at work, the basis of selection only being altered by man. The river flows according to the same laws over a natural ledge of rock or over an artificial dam.

Hybridization, as above shown, may produce species as well marked and as fertile as any natural species. But no wild species is known to have arisen from this cause, unless we regard the warbler, *Helminthophaga leucobronchialis,* as an established species.

A saltation or mutation, beginning with an individual, may extend its characteristics to a numerous progeny, thus forming the beginning of a species. But while this influence may in theory, or even in fact, have a large importance, it is not likely that many species originate in this way. There is no clear evidence that any wild species known to us has arisen from a sudden large individual variation or mutation.

Orthogenesis

A large number of unexplained, but apparently related, phenomena have been recorded under the name of determinate variation, or have been grouped together as examples of a process to which Eimer has applied the name of Orthogenesis.

Setting theory aside, these cases are essentially of this character. In geological times a certain number of genera appear, each one in a certain direction farther along than its predecessor. Very often a certain organ will be progressively more and more highly developed until a certain point, when it is progressively degraded or simplified in its structure. Examples of this are found among the ammonites, or cephalopods with coiled shells, the chambers in the cell elaborately sculptured. Many illustrations are found in the group of fishes. Coats of mail may be built up step by step, genus after genus, and then gradually modified or abandoned. In the *Chætodon-Zanclus-Acanthurus-Balistes-Tetraodon-Diodon-Mola* series of fishes, we have a high development and specialization of the spinous dorsal followed by its entire loss step by step, with that of the ventral fin also. The scales, at first normal, are specialized to lancets, bony plates, spinules, and then gradually reduced to mere prickles and finally lost.

In the *Cirrhitus-Sebastes-Scorpæna-Cottus-Psychrolutes-Cyclopterus-Liparis-Paraliparis* series, we have a higher and higher specialization of fins and scales, with the final loss of the latter and a reduction of the fins to their lowest terms. Similar series connect the typical sharks with the rays. Other series among fishes begin with specialized forms, but end in the degeneration seen in multiplied and unspecialized vertebræ and fin rays. The well-known horse series and the series of monkeys and apes—each genus in certain lines being progressively more anthropoid—may be considered in this connection. In fishes, many of these series may be clearly traced among forms still existing, the most primitive as well as the most recent or degenerate types being still represented in the sea. But, in a general way, when the geological series is known, it is found to run more or less parallel in time to the progressive changes we must imagine to have taken place. On this fact most recent paleontologists seem to be agreed.

While the phenomena exist and must be reckoned with, the causes are by no means clear. Perhaps the continuous operation of some form of selection may be conceivably potent in some cases. But the more primitive types still retain their vigor and abundance, and this fact must not be overlooked in our explanation. It may be noted that these series, as usually recognized, are made up of genera, each genus a step in some definite direction, with numerous diverging steps at the same time. But there is no evidence that the organisms in question individually vary in any one determinate direction, or that the tide of heredity is swayed by the forces which make for orthogenesis. Most naturalists disclaim any teleological implications in the terms used to describe these phenomena as 'determinate variation.' It is sufficient that it would seem that the line of succession of genera is determined by unknown causes, causes other than those potent in producing the divergence of heredity which we call the origin of species.

We may perhaps find some clue to these matters in the phenomena of analogous variation. Like conditions produce analogous results on forms of very different origin. Osborn notes that nature has often a very limited range of responses to external conditions. In upwards of a dozen different groups of fishes of widely different relationships, nature has developed gar-like jaws. In several different groups (*Harriotta, Polyodon, Mitsukurina, Pegasus*), she has produced forms with the upper jaw produced into a flat blade. In numerous unrelated groups of fishes, she has produced genera with the parrot's beak (*Scarus, Oplegnathus, Tetraodon*), or with an imitation of human incisors. In many different wholly unrelated groups she has developed bony plates, hardly to be distinguished superficially from those of her ancient ostracophores and dipnoans. Thus the earlier writers placed with the ganoids such forms as *Callichthys, Ostracion, Agonus, Pegasus, Hippocampus, Gasterosteus, Peristedion,* forms now known to have no affinities with the extinct mailed fishes, and for the most part no affinities with each other.

Such adaptive characters do not suggest relationship. They are mostly superficial only, and indicate not the origin or affinities of the forms possessing them, but rather the habits of the species in question, and the needs of their recent environment.

In finding what an animal really is, that is, in tracing its ancestry, we have in the words of Haeckel, mainly the three ancestral documents, morphology, embryology and paleontology. Adaptive characters are essentially external. The inside of an animal tells what it is, the outside where its ancestors have been. Perhaps a fuller understanding of orthogenesis will relate its facts to those of 'analogous variation' or the 'convergence of characters' in unrelated forms.

THE HUMAN SIDE OF THE INDIAN

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THE oneness of the American Indians with all races of men (including us whites) is readily admitted by those who have seen them in their human activities and not merely in their forced relations with so-called 'higher civilization.' The writer was fortunate enough, a number of years ago, to come into the friendliest contact with the Kootenay Indians of northern Idaho and southern British Columbia, one of the least spoiled aboriginal peoples of the continent, and brought back with him to the east many pleasant experiences and reminiscences of 'savage' life. Since that time the building of the Crow's Nest Pass railroad and the opening up of the Kootenay district consequent upon it have made impossible some of the incidents occurring during his visit as an investigator under the auspices of the British Association for the Advancement of Science.

The Kootenays are very fond of their children, the men much more so than is commonly believed, or even supposed. To see a man carrying a little child is by no means a rare sight. Among the Lower Kootenay in Idaho, the writer saw one of the older men of the tribe playing in right human fashion with his children. The little ones ran merrily all about him, pulling his hair, pinching him, etc. One little tot of some five years of age persisted in crawling all over him. He was very affectionate toward them and even allowed this child to put its toes into his mouth. Surely the white man could go no further!

About the same time, a young woman of fifteen was busy chopping firewood—and she handled the axe remarkably well. After carrying on her back to the tent the wood she had cut to pieces, she looked around for a little girl of five or six who was amusing herself at a distance. '*Tláne! tláne!* (Come! come!),' she cried loudly, but the child did not or would not hear. Soon she ran over to the child, caught her, spanked her and brought her home. The spanking was quite after the fashion of the whites, and was probably learned from them, as that method of punishment is un-Indian. The Kootenays seldom, if ever, whip their children, and one of them said that he would rather die than see a white man chastise his offspring. At one of the stores in the Upper Kootenay country a little Indian boy was playing 'hide-and-seek' with a little white girl as blithely as might be. This same little fellow, whose skin seemed even dirtier than the shirt forming his only garment, was promised some candy if he would wash his face. Going to the river, a few yards off, he marched in, clothes and all, coming back dripping from head to foot, but beaming with smiles. The candy he ate in a way that would do credit to any white child. Not alone the children, but the adults as well, are very fond of candy, which they call *gāktlētl k'kōk'tsi,* or 'variegated sugar (sweetness).'

On another occasion, and at a different place, the writer had a little Indian boy to breakfast with him. After the first shyness was over, the little fellow conducted himself with a grace and dignity quite unknown to many white children of his age. And through it all his beautiful dark-brown eyes shone in the most captivating fashion.

At the Mission of St. Eugene, on the St. Mary's river a few miles from Ft. Steele, B. C., a school of a more or less industrial character had been established, and, at the time of the writer's visit, was attended by about sixteen girls and ten boys, a number of whom were of mixed blood, children of white men who had married Kootenay women. The school was conducted by members of one of the Catholic sisterhoods, under the superintendence of Father Coccolo, the resident missionary, who exerts a great and abiding influence over these Indians, who thoroughly appreciate his absolute devotion and self-sacrifice. The children, who were from seven to fifteen years of age, showed gratifying progress in their attempts to acquire some of the learning of the whites. Although they had been in attendance only a few months, some of them could already read from 'Sadler's Dominion Catholic First Reader,' and sang also, not very badly, 'God Save the Queen,' and 'Great and Glorious St. Patrick,' which seemed to be their *pièces de résistance.* Some could write a very fair hand—it is curious with what facility the Indian can often master this art as compared with his white brothers under similar circumstances. It should be mentioned in this connection that many of the Kootenays, as their drawings made for the writer indicate, have a good graphic sense. They can likewise draw maps and recognize on the maps of their country made by white men the chief topographical features. No extensive carvings on rocks or pictographic records have been reported from their country, however, the 'Painted Rocks,' on Lower Arrow Lake, being quite within the territory of the Salish Indians, and not belonging to the Kootenays. While in the Lower Kootenay country, the writer received from the daughter of David McLaughlin, from whom he collected many native texts of myths and legends, the Kootenay equivalent for 'God save the Queen,' which is presented here as a literary curiosity:

Gā́mnākōtlṓkōníqan
May he save
Yā́kasinkínawā́skē
He who made us

Gūwítlkā nāsūkwin pắtlkē!
Great woman chief!

On a Sunday afternoon, which is the holiday of the week among those Indians more or less under the influence of the Roman Catholic missions, the Lower Kootenays indulge in horse-racing, or, more properly, horse-running, on the great grassy plains beside the Kootenay river. Their whole herd is collected in an open space near the camp and then driven in all directions over the prairie and through the bushes, chased by laughing and shouting Indians, armed with quirts, willow gads, etc. The horses are run down, tripped, lassooed, driven into the water. Some of the Indians took particular delight in driving the horses as close as possible, in full course, to the writer's tent, to his evident embarrassment, which they keenly enjoyed. As horse after horse thundered past, at very close quarters, shouts and peals of laughter would fill the air, accompanied by remarks in the native language provocative of still more amusement. While all this is going on, the children sport about in the bushes, or caper about in the plain, seemingly in imminent danger of life or limb. It is very interesting to see them chase one another with long whips, or try to lassoo each other. Often they attempt to run down or lassoo the colts or the tamer horses, and the skill some of them develop in so doing is really surprising.

Many of the Indians are quite fond of their horses and treat them better than do the white men. Some, however, use only too readily the spur and the heavy whip of the whites. The Indian Amelu, when out on the trail with the writer, even when the horses had no packs to carry, would walk them up and down the steep grades and was in other little ways 'merciful unto his beast.' In the Upper Kootenay country, an Indian was seen to beat cruelly with his whip the dog of a Chinaman, which had tried to bite the toe of his moccasin, after having been teased for a long time. Some of the younger Indians are rather companionable with their horses, and it is worth noting that they have coined a few slang words, such as *k'ădla,* instead of *k'kătlahắatltsin,* 'horse,' and *mistak'ădla,* 'colt.' The Kootenay name of the horse bears witness to its exotic origin, for it signifies literally 'elk-dog,' these Indians having had recourse to the aspect of these two animals already familiar to them, in order to assign a name to the new creature, the horse, introduced by the neighboring Indians directly or indirectly through the whites. Other animals not originally natives of the Indian country have sometimes very interesting names. Thus, the cow is 'the variegated horned animal'; the pig, 'the cut-off nosed'; the mule, 'the big ear'; the hen 'the variegated tail,' or 'the spotted tail,' or, again, 'the prominent tail'—these names applying particularly to the 'rooster.' Some of the names of plants new to the Kootenays and introduced through the whites are: Cabbage, 'edible leaf plant'; cucumber, 'plant that grows on the ground wild'; oats, 'horses' food'; orange, 'big rose-hip' (the apricot, peach, pear, tomato, apple, are all named after the hip of the prairie-rose). The daughter of David McLaughlin, of the Lower Kootenay, a *métis,* who spoke only Kootenay, coined for the writer a new word on the spot. This was a name for the sunflower, which she called *kākắdlimū́kōwādl̄ídl'yit,* which seems to be derived from the word for 'light.' The Indian Amelu was not nearly so ready to assign names to new things—it is probably true that women exceed men in this respect among some primitive races. When asked to name a strange plant Amelu would often reply simply, *nōtlūkinē,* 'it is strange (foreign, unknown),' or *tsákō nána,* 'it is small (a little thing),' or, again, *hòk·ā ṓphanē,* 'I don't know.' Still Amelu did know a great many things, for one evening he reeled off 91 names of birds. On other occasions he had named over 100 species of plants, shrubs and trees, besides a large number of animals, fish, etc. Of every one of all these he was able to give brief descriptions.

When a scientific investigator first makes his appearance among a primitive people, it is often difficult to convince them that his advent is not connected with the attempts of white men to steal their land or ill use their women—these are the two chief sins laid to the charge of the 'superior' race. The writer once by accident intruded on what might be called the meeting of the 'sewing circle' of the Kootenays, but the shouts of the women immediately reminded him of breach of primitive etiquette he was committing by peering into the women's tent. One of the chief men of the Upper Kootenays, who was unfriendly to the writer's objects, resurrected a dead-letter law of the tribe by which the women were forbidden to talk English with the white men. When the writer overcame this difficulty by using the Chinook jargon, the same man used his influence to have the women forbidden to talk anything but Kootenay, but by that time he had learned enough Kootenay to make this prohibition of not much avail. Some of the Indians understood very readily the idea of having their language and their legends preserved by means of the white man's records, and took the utmost pains to secure accuracy and completeness. Amelu was so interested in the matter that he suggested a new method of procedure, *viz.,* that the writer, if he really wanted to make the best possible investigations and record everything, should marry the niece of the old chief, who was about to resign office—the inheritance was in the female line—and thus become chief of the tribe, when he would be able to accomplish his heart's desire in the way of scientific knowledge. The ties of his own people, naturally, prevented this consummation, which certainly would have had its advantages for science, for as chief of the Lower Kootenays the writer might have accomplished much.

The reactions of the Kootenays to the proposal to have their stature, etc., determined were often very interesting. Most of them at first refused altogether, and their prejudices were very difficult to overcome. One Indian told the writer that he could measure him when dead, and another said that he was not a child—others, however, were very unwilling that their children, in particular, should be measured. To measure the women, was, of course, except in rare instances, impossible.

With the language it was different. The Indians would often come to the writer, without having been asked, and inform him that they had some words which they wanted him to put in his 'book' of their language, so eager, apparently, were some of them to help in the preservation of their speech. This is a rather common experience with those who have come into sympathetic relations with savage and barbarous peoples. Amelu, after he had told the writer a great many things about himself and his people, would sometimes turn round and catechize his catechizer, asking him all manner of questions about the whites, their manners and customs, etc., showing great interest, and being sometimes much amused. 'What do you call this in your language?' he would often ask, as he came across something new or interesting. 'Haven't you white people any stories about Coyote?' he would say, after relating some of the Kootenay legends. Once, when an Indian was asked to tell the story of the sun and moon, he began to give a version of the Bible account of the creation, as he had it, probably from some priest. He appeared surprised when the writer informed him that that was the story of his people, and after a little while admitted that it wasn't Indian, and began to tell the Kootenay story of how the coyote and the chicken hawk made the sun and moon. Amelu, who was an Indian under mission influence, did not hesitate to shoot a chicken-hawk for the writer, although that bird is one of the chief figures in Kootenay mythology—he had more fear of 'medicine-men' than he had superstitious views of mythological personages. He would not eat meat on Friday, but would eat the 'saw-bill' duck, which, he declared, ate so much fish that it was practically fish itself. Another 'religious' practise of his was wearing the old Indian breech-clout, even when he had adopted the trousers of the whites. In a few other respects also he was a curious mixture of the old and the new.

The Indians are very prompt to notice any personal peculiarities or idiosyncrasies of speech, action, movement, etc. In climbing into the saddle the Kootenays swing off the right foot, and not off the left, as does the white man. The fact that the writer (amateur in his horsemanship) happened to climb into the saddle 'off-side,' as we say, gained him at once the name, 'The man who rides like an Indian.' This circumstance was a road to the favor of these people, who are always delighted to have one do instinctively as they do. The mastery of the difficult *k* and *tl* sounds, so characteristic of the Kootenay language, is also much appreciated by the Indians. This will be easily understood when one learns that, in the mouths of the whites the word for 'horse,' *k'kātlahaatltsin,* is made over into kallahalshin, or worse, while the distinction between words of entirely different significations, *e. g., g· ūstet,* 'trout,' and *k· 'ūstit,* 'tamarack,' is altogether ignored. His attention to these points caused the Indian to dub him 'The man who talks straight.' A third name conferred upon him recorded the fact that he never lied to them. In another the Indians called attention to his very dark hair, 'The man with hair like an Indian'—the possession of which was another bond of union with them. A fifth, and more formidable name, 'He uses the long stick'—he owed to the anthropometric apparatus which he carried with him. By use of these various names the coming and going of the writer was heralded all over the Indian country and the natives soon came to know him well and understand the reason of his presence among them. Some of the white settlers have also received interesting nicknames, one prominent individual, who had a glass eye, being termed 'The man who takes out his eye,' and the Indians are clever in their imitation of his manipulation of it.

To hear a white man blundering along in his efforts to speak Kootenay correctly is one of the best quarter-hours the Indians ever enjoy. Even the wives and children of white men who have married squaws extract considerable amusement out of the linguistic mistakes of their husbands and fathers. Any one who believes that the Indian never laughs will be heartily undeceived after a session of this sort. The inability of the whites to master the numerous gutturals with which the Kootenay language is provided is a never-ending source of laughter. The Indians went off into roars of merriment over such mistakes as saying *inisin* (horsefly) for *inisimin* (rainbow); *k'ūpi* (owl) for *k'ūpōk* (woodpecker); *hāhās* (skunk) for *hāhā* (crow), etc. When some one said for *kānkūptsē* (bread baked in a pan), the perfectly unmeaning *tankūptsē,* it reminded the Indians of a real word, *t'ānkūts* (grouse), and they indulged in a fit of laughter. When the writer mispronounced the word *g· ūstet* (trout), on one occasion, an Indian went off into the woods near by and returned with a diminutive 'tamarack,' the name of which is in Kootenay *k· 'ūstit,* pronouncing that word correctly, as he handed him the shrub. The writer's desire, which the Indians fully comprehended, to obtain a large vocabulary and a considerable body of texts of myths and stories in the native language led naturally enough to the very embarrassing demand that he should read every word and every sentence over and over again until he could repeat them all without the slightest error—this was worse than the child's well-known demand for the repetition of its favorite stories without any deviation from the original text, since he could often write down the word correctly, when he could hardly satisfy the Indian's requirement in the way of pronunciation.

The Indians have their 'chatter' and 'nonsense' as well as the whites. Amelu was very fond of chanting and talking to himself in somewhat waggish fashion. This he called, in the Chinook jargon, 'cultus wawa' (nonsense). As he sped along the trail he would sing to his horse, slapping it on the flanks, or making rhythmic motions with his hands:

Tō tō tō tō!
Tum tum tum tum!
Tā tā tā tā
Tai tai tai tai!

The repetition was *ad libitum*, according to his mood, or his fancy. Another refrain, which had an 'infinite variety' of inflection, intonation, etc., was the following, which he sang with great animation:

Hai yā! hā hē yau!
Ē yā! hā hā hai yau!
Hē yā! hō yō!

This sounds a good deal like some of the refrains used in the gambling games of the Kootenays. Another refrain, which he chanted as the fire was being spoiled by the scattering of the burning logs, was:

Hum kē pupum!
Hum ke̠ pupum!

An interesting procedure, indulged in often by Amelu, was the mispronunciation and distortion of words, amounting not seldom to real punning. Thus for *saiwáskō*, the name of a species of dragon-fly, he would repeat: *Saiwāsukw', sauwātskō, sauwásko, saiwāsekō, saiwātshkō*, etc. Sometimes when the Indians were telling legends in their own language, they would deliberately mispronounce or distort words to see if the writer noticed the difference—if he did not at the time they would generally tell him, and have a little fun over it. When they came to the parts of the stories where the animals played tricks on one another they would stop to laugh over it, making fun of those who couldn't talk very well. The Indians would laugh to themselves when the writer used a proper Kootenay term, and one of the other white men about a slang or jargon term without knowing it.

While the writer and Amelu were out botanizing and sampling every edible berry (the Indian, of course, tasting first), they ran across the 'soap-berry' (*Shephardia canadensis*), the *gōpātētl* of the Kootenays. The wry faces made by him as he chewed up a few of the berries, greatly amused his guide, who explained that the Kootenays did not like these berries half as well as did the Shuswap Indians, for they 'tasted like bad whiskey.' It may be said here that the Kootenays have many names, but little use for whiskey, both on account of their own inclination against it, and by reason of the stringent laws and the good influence of the Catholic missionaries—the miners also, as a mere matter of self-defense, aid in the thorough enforcement of the law. The story is told of a Kootenay who, when sick, was told by a priest to take a little whiskey as medicine. He sturdily refused, with the emphatic declaration: 'You say whiskey bad. Bad one time, bad all time.' Poetic justice was satisfied by the recovery of the patient. The Indians are very skilful in their mimicry of the drunken white man. Among the Kootenay names for whiskey are the following: *wūō* (water, liquor), *sūyápi wūō* (white man's water), *nipik· ā wūō* (spirit water), *nōtlúkinē wūō* (strange, foreign water).

After the tasting of the berries was over, Amelu took pleasure in crushing some of them between the palms of his hands and showing how 'soap' could be made. The leaves of the shrub he then used as a very primitive towel. Other experiences of the writer on this excursion convinced him that the Kootenays are not without a sense of humor. On the Mooyai trail the writer ran into a group of nettles, and Amelu hugely enjoyed his surprise at being stung.

This humorous reaction to the surprise, embarrassment, awkward predicament, accidental discomfiture, etc., of a fellow man is common among these Indians, both with reference to their own tribesmen and to individuals of other races, such as whites and Chinese, with whom they come into contact. In the region of the Columbia lakes, there are a cold spring and a warm spring (not steaming so as to be noticed) close beside each other, and a common trick of the Indians is to induce an unsuspecting stranger (red or white) to step into one immediately after the other. The writer, upon the suggestion of Amelu, once took a plunge in the Kootenay at Ft. Steele, but did not stay in more than a moment. The water was almost icy cold, as the Indian knew, by his own confession, and the haste with which his white friend got out of the water stirred deeply his sense of the ridiculous. Similarly, whenever the Indian horse threw him off into the pine-brush or cast him over its head into a creek, his guide would feel bound to laugh more or less heartily. Another fertile source of amusement was the embarrassment caused the writer by his first acquaintance with the snapping and snarling, no less than thieving, Indian dogs, who were the pest of the camp. One of these curs actually seized hold of a can of corned beef and was running off with it, when the use of another can as a missile caused him to give up his plunder. This action must have seemed very funny to Amelu.

This sense of humor is collective as well as individual. The writer was present beside the camp-fire one night, when one of the Indians was giving, for his benefit, an account of a government official who had recently 'inspected' the Canadian Kootenays. This individual was said to have insisted on taking with him all the appurtenances and conveniences of civilization, including a cook-stove, a feather bed, etc., and the group of listeners expressed loudly their merriment, as the speaker touched off the white man's peculiarities. The Indians were fully conscious of the fact that another official (likewise another white man, a storekeeper) was really very much afraid of them. They made this known to the writer in sarcastically humorous fashion. Indeed, the white settlers hardly are aware how much the Indians comment upon their appearance, their character and their actions, especially in a quasi-humorous way. One Indian actually told the writer, with 'fun' in his eye, however, the order in which the white people would be killed off, should trouble ever occur—a certain settler, who could see nothing good in the Indians, was to be the first victim, and the writer (if he had to be included) was to be the last.

The Kootenays take delight in playing tricks, not only upon one another, but also upon the whites. The writer had complained of the first horse procured from them as being altogether too fast for his liking and too 'wild,' so the next time he asked for a horse he was given a creature, which, except when he was in the company of other Indian horses, went at less than the proverbial snail's pace. The writer's indignant remonstrances evoked abundant mirth on the part of the 'guileless' natives. While measuring an Indian in the Lower Kootenay country, he had an experience of a more startling sort. The Indian suddenly rose to his full height, and, quickly drawing his knife from its sheath, pretended to strike him—the writer being soon reassured, however, by the loud laughter of the other natives about him. Tricks like this are much enjoyed by them.

In the mining regions of the Kootenay country, there are a considerable number of Chinese, who have taken up the claims abandoned by the whites, and manage to make a good living from them. The superior attitude assumed toward these people by the whites has its effect in the way the Indians look upon them. As a rule the Kootenays and the Chinese get along well together, but the former sometimes hector and bully the latter, and not infrequently Indians become semi-parasitic, doing odd jobs for the Chinese, or imposing upon their charity. Many of the Indians regard the Chinese as quite inferior beings, and the poor Celestials seem in more or less awe of them. In jesting fashion, the Indians will call the Chinese 'brothers' or 'cousins,' but persistently deny any close relationship. One of the Kootenays, who knew that the whites thought the Chinese and Indians looked alike, pointed out to the writer several differences between them of a physical character, and then remarked, in the Chinook jargon, 'halo siwash'—not Indian. The single braid, or 'pig-tail' of the Chinese is a matter of sport for the Indians who usually wear their hair free, or in several braids. The Kootenay name for Chinaman is *Gōōktlām*, or 'tail head,' in reference to the hair-braid. The Indians also make fun of the alleged use by the Chinese of cats as an article of food. One of the Chinese of Wild Horse Creek, a certain Lam Kin, acted as 'doctor' for some of the Ft. Steele Indians, his cure being a sort of medical tattooing, known by the Indians as *katlku*, which many of them affected after their own ancient shamanism had been more or less abolished through missionary influence.

One afternoon, when camped in the Lower Kootenay country, the writer thought he detected the presence of a skunk in the vicinity of the tent. He saw his Indian guide some distance away and hailed him about it. Only a non-committal answer was obtained. Noticing that the Indian did not venture to come near, he asked him what he had been doing, and started to go toward him, when he soon perceived what was the matter. Amelu had been trying to kill a skunk, and his scanty raiment exhaled abundant evidence of the encounter. He was given some money to get new clothes at the little store not very far off, and soon returned in triumph, having taken a bath in the river on the way back. How he induced the storekeeper to let him get near enough to purchase what he wanted he did not say, but perhaps the exchange was effected after the primitive fashion sometimes indulged in by children. However that may be, Amelu was a thoroughly shamefaced red-skin, as he stood off at a distance, afraid to come near the tent until the cause of his embarrassment had been disclosed. It appears that the Chinese in the mining districts of the Kootenay use certain parts of this animal for medicinal purposes, and the Indians catch them and sell them. Some of the Kootenays are said to catch skunks with their naked hands—usually they knock them over with sticks or stones. In capturing these and other small animals they take pleasure in getting as close to them as possible before striking. When using the writer's gun, Amelu would creep up so close to the grouse, known locally as 'fool hens,' that they would be blown to pieces when he did discharge his weapon. He also appeared to take great delight in 'gaffing' fish as compared with catching them with hook and line, although he enjoyed that very much, especially when he became aware of the writer's inexpertness as a fisherman.

Past one of the camping-places on the Kootenay river a steamer used to go every few days, and Amelu, from the moment he first heard the whistle till the vessel disappeared from his sight, would stand upon the bank waiting for it, gazing at it, peering after it. The sound of the whistle never failed to arouse him, or to call him forth, wherever he might be, and the steamboat was, doubtless, one of the wonders of his life. When a trip up the river, from the international boundary to the settlements on Kootenay lake, was proposed, he was beside himself with joy and anticipation. He became excited beyond all bounds, and when the whistle sounded danced with delight and capered about, not exactly like a gazelle, for he weighed 177 pounds and was heavily built. When he got on board and could examine things at his leisure, he was 'tickled to death.' He inspected everything that was at all accessible, watched the motion of the vessel and the revolutions of the wheel, listened to the noise of the engine and the hissing of the steam, gazed in rapt wonder at a score of different things that from time to time riveted his attention. But his keenest delight, after all, was when he could signal or shout to some of his tribe on the banks or in canoes in the stream. The relish with which he did this was unmistakable. And, on the journey back, he was quite as elated, if not so inquisitive. Certainly that trip on the 'fire canoe' was one of the events of his life.

The 'fire canoe' seems to have appeared more natural to the Indians than the locomotive, or 'fire wagon,' possibly because of its progress in the water, like a canoe, and not over the land with the 'fearful eye' of the latter, which so impresses many primitive peoples. In northern Idaho the Indians were very much frightened by the first steam trains. When the railroad was near Rathdrum, several Lower Kootenays, who had been sent into that part of the country to deliver some letters, were so affected by the sight of the puffing, snorting, fire-spouting locomotive that they threw down their letters on the spot, turned about and fled for dear life, not daring to look back once until they were safe again with their own people. They reported that they had been chased by the 'Evil One,' himself, and had escaped with the greatest difficulty. Later on, as happens with other peoples, familiarity bred contempt, and the Indians can now look at these creations of the white man's genius with much less of fear than of wonder or of interest. The Kootenay youth is more afraid of doing 'woman's work' than he is of the 'fire-wagon.' This was the case with Amelu, the writer's guide, who was with difficulty persuaded to make his own pan-bread on the trail. He was '*hiyu* shame' (much ashamed), and used to make it always before an Indian camp was reached. In other things also, he shared the disinclination of his fellow tribesmen to perform any labor that properly belonged to women, according to the customs of his people.

Some writers would deny to the American Indian all possession of romantic love, or of love in any very high sense of the term. This, of course, is an utterly untenable theory, as any one who has seen the Indian at home well knows. The writer's 'guide, philosopher and friend,' Amelu, a young man of 22 years, was in love all the time he was with him, and gave expression to many of the orthodox symptoms of that state in an undoubted fashion. The shamefaced way in which he would answer when asked why he had been away from the tent (in the neighborhood of an Indian encampment) so long the night before was a convincing fact. One evening he asked for a little money, and no amount of coaxing would for a long time induce him to say what he wanted it for. At last, however, in real lover fashion, he admitted that he wanted to buy some article or other to take to his lady friend, who was to put the finishing touches upon it. On this occasion Amelu blushed as much as the redskin can, and that is a good deal. Altogether, as an eminent Americanist once said, the Indian is a man, even as we are men. This the writer knows by actual experience, from the moment of his first arrival among the Kootenays, when *halo naika cumtux* (Chinook jargon for 'I don't know') was the only conversation on their part, to the time when he sat with them, round the campfire and himself began the story-telling: *Kānáqē Skínkūts,* 'The Coyote was going along.'

THE FRESH-WATER FISHES OF SOUTH AND MIDDLE AMERICA

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A. The salient features of the fish fauna of the Americas south of the United States are:

1. Great variety of fish life in the area between the Caribbean Sea and the Argentine Republic.

2. Paucity of 'types' or families contributing to this variety.

3. Paucity of the middle American fauna and its essentially South American character except for

4. the isolation of the fauna of the Mexican plateau.

5. Paucity of the Pacific slope fauna and its essentially Atlantic slope character.

6. The 'marine' character of the Titicacan fauna.

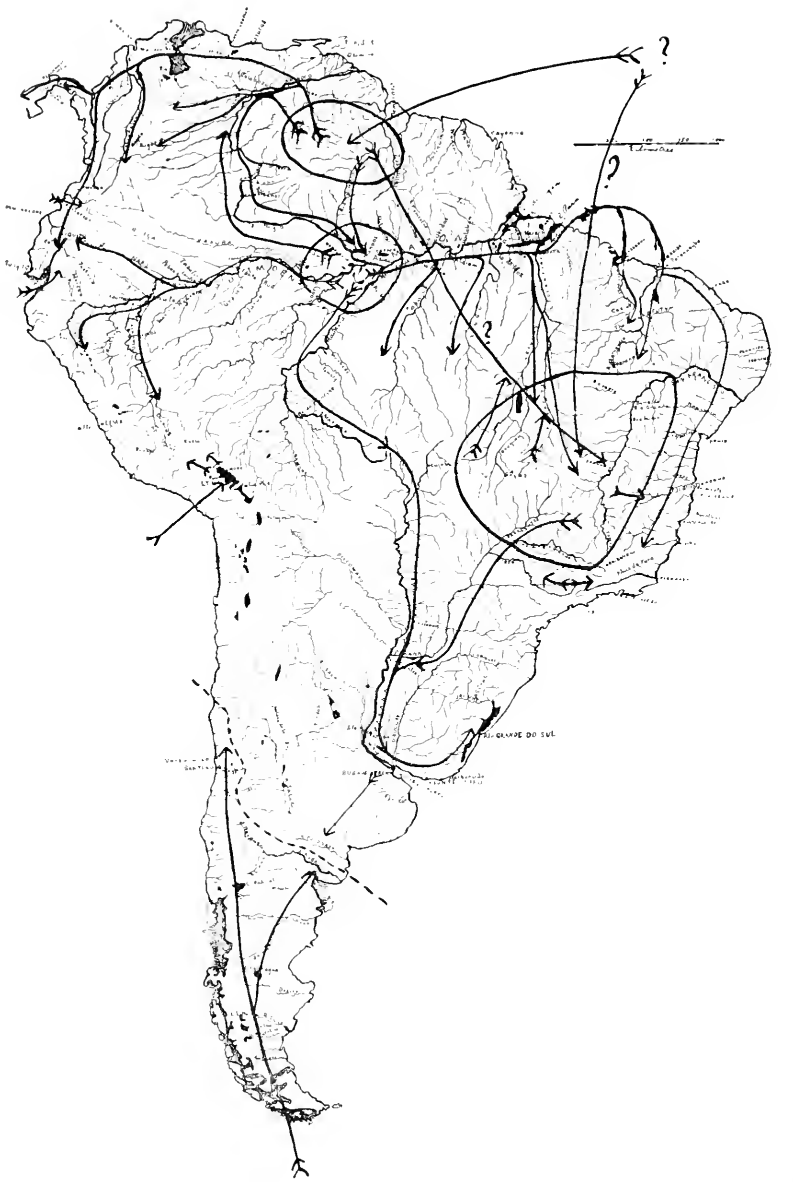
7. The paucity of the Patagonian fauna and its essential difference from the Brazilian fauna.

8. The similarity of the tropical American to the tropical African fauna.

The first fresh-water fishes of South America were described by Marcgrav in 1648. Additional accounts were given by Gronow, 1754 to 1756; Scopoli, 1777; Bloch, 1794; Lacépède, 1802; Bloch and Schneider, 1807; Cuvier, 1817 to 1818.

In 1817 the king of Bavaria sent Spix and Martius on an extended trip to Brazil. Spix was working at the report on the fishes when he died. The collection was turned over by Martius to Louis Agassiz, a student of twenty-one at Munich. It had been nip and tuck between Agassiz's desire to study natural history and his father's desire to have his son study medicine. The commission to work up the Brazilian fishes was surreptitiously undertaken by Agassiz and the results published in a superb folio volume. This work, which tinctured the entire later life of Louis Agassiz, was by far the most important contribution to the fresh-water fishes of South America that had appeared. Agassiz's desire to visit Brazil himself was not fulfilled until forty years later, when, as the head of the Thayer expedition, he spent sixteen months in Brazil with twelve assistants, devoting his time mainly to fresh-water fishes.

I was a student under Jordan when Mrs. Agassiz's 'Life and Letters of Louis Agassiz' appeared in 1885. Agassiz's account of his expedition to South America, coupled with the statement of Jordan that no



SOUTH AMERICA—the hypothetical line of demarcation between the Patagonian and Tropical American fauna marked - - -. Centers of distribution in unbroken circles, and hypothetical lines of migration by arrows.

comprehensive account of his collections had ever been prepared, created the desire to examine this lavishly rich fauna. In the fall of 1887, with Mrs. R. S. Eigenmann, I began work on Agassiz's unrivaled collections, to which I had gained access through the courtesy of Mr. Alexander Agassiz, the director of the Museum of Comparative Zoology, and Mr. S. Garman, the curator of fishes. Financial and other reasons compelled me to abandon the work when but half finished. Occasional collections received from South America for identification have, however, kept up my interest. The entire problem presented by this fauna has been reviewed and will be published in one of the reports of the Hatcher expedition to Patagonia. I am permitted to publish this summary of results through the courtesy of the editor of the Hatcher volumes, Professor W. B. Scott, of Princeton University.

1. *Variety of Fish Life.*

On February 23, 1866, Louis Agassiz wrote to the emperor of Brazil:

> I estimate the total number of species which I actually possess [from the Amazon] at eighteen hundred, and it may be two thousand.

> To this is added a footnote in Agassiz's 'A Journey in Brazil,' p. 383.

> To-day I can not give a more precise account of the final results of my survey. Though all my collections are safely stored in the museum, every practical zoologist understands that a critical examination of more than eighty thousand specimens can not be made in less than several years.

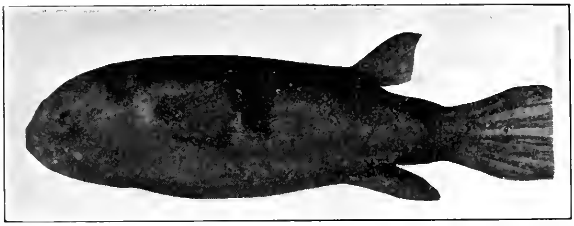
Agassiz secured more species from a small lake in the valley of the Amazon than there are in all the fresh waters of Europe.

The number of species he collected was overestimated by Agassiz. While about half of his Amazonian collections have not, after forty years, been examined, it is certain that the species not yet examined will not swell his list to 1,800 species. The total number of species recorded from the Amazon basin up to date is 674.

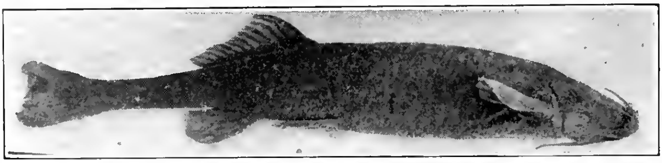
Although Agassiz's estimate of the number of species he collected is too high, the total number of species found in South America is very great. About ten per cent. of all the known species of fishes have been recorded from the freshwaters of South America. In 1892 I estimated that three fourths of the fauna was known. Now, after examining recent lists, and considering that collections have largely been made in easily accessible and great highways, and that from great river basins like the Purus, Tapajos, Xingu and the Uruguay and the greater part of the Madeira and the Tocantins we have nothing at all, and that even from the great Orinoco and Magdalena we know next to nothing; I doubt very much if we even yet know so much as three fourths of the fauna of the area between the Caribbean Sea and the Argentine Republic.

The tropical American fresh-water fauna, having its center of greatest diversity in the middle Amazon basin, is attenuated northward till it reaches the vanishing point just on the borders of the United States. Southward it extends to somewhere—no one knows where—south of Buenos Aires. The Patagonian fauna and North American fauna are entirely different from the tropical American fauna and from each other.

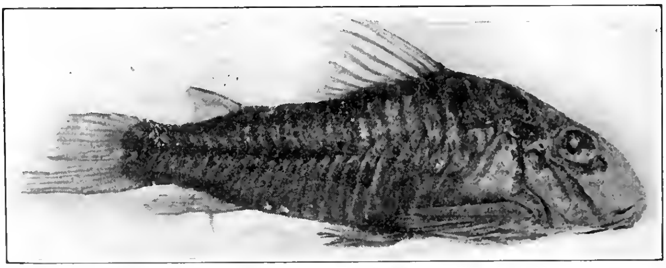
The key to the great diversity of the tropical American fauna is to be found in the enormous single water system, extending from 10°



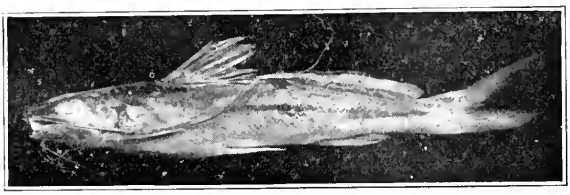
1. *Calomesus psittacus* (BLOCH & SCHNEIDER) A MARINE TYPE WIDELY DISTRIBUTED IN THE RIVERS.



Hatcheria, A MOUNTAIN CATFISH. RELATIVES OF THIS SPECIES RANGE FROM VENEZUELA TO PATAGONIA.



3. A *Corydoras*, AN ARMORED RELATIVE OF THE CATFISH



4. *Pimelodella gracillis* VAL., ONE OF THE SMALLER CATFISHES ABOUT NATURAL SIZE.

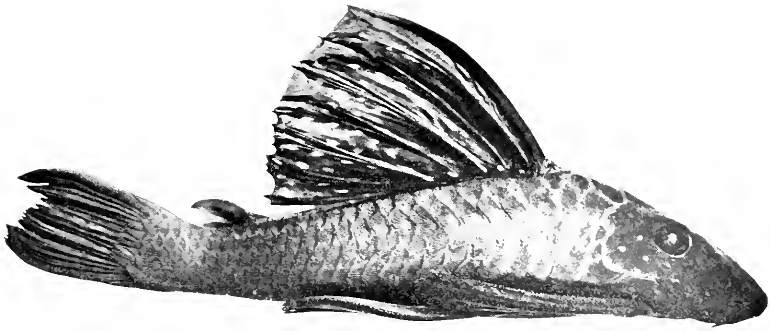
north to 35° south latitude, and from 50° to 79° west longitude, providing a continuous north and south waterway of more than three thousand miles, and an east and west course of over two thousand miles, and embracing the Orinoco basin, the Amazon basin and the La Plata basin, draining over 3,000,000 square miles of territory, or an area about equal to that of the United States, exclusive of appendages.

2. *Paucity of Types.*

There are found in the rivers of South America representatives of many marine fishes. Soles, swellfish, stingrays, needlefishes, mullets, sciænoids and the herring tribe give to the South American fauna a peculiarly marine flavor. But all these form but a small fraction of the entire fauna, and their elimination would make little inroad on the number of species. All are recent additions from the sea.

There are also in South America a number of undoubted relicts of former times, and if one should judge by the interest excited by the genera *Synbranchus*, *Lepidosiren*, *Arapaima* and *Osteoglossum*, it would seem that these genera formed an important element in the present fauna; but they are so few in number that they also might be eliminated without any appreciable depreciation in the variety of the South American fauna.

After eliminating these, then, we come to the reigning element in the present fauna, the element now in its prime and best suited to contribute to the elucidation of the methods and paths of divergent



5. *Doras dorsalis* C. & V., AN ENCRUSTED CATFISH.

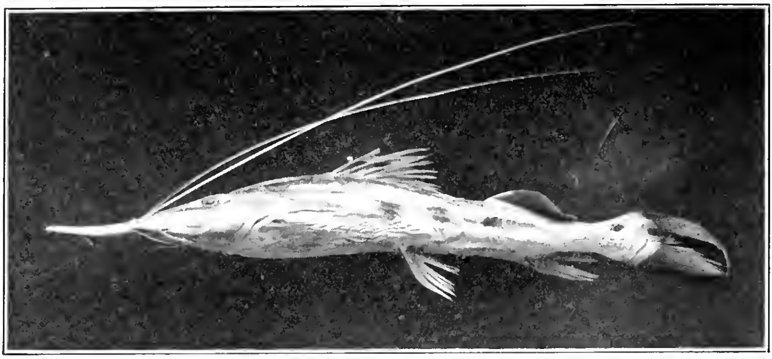
and convergent evolution and the paths of dispersal. Chief of these elements is the superorder Ostaryphysiæ, composed of the Characinidæ with about 500 species; the Gymnotidæ with about 30 species, and the various families of catfishes with about 500 species. Pœciliidæ, dominant in middle America, contributed materially to the fauna—about 45 species.

The largest contribution, aside from the characins and the catfishes, is furnished by the Cichlidæ, with about 145 species, in south and middle America.

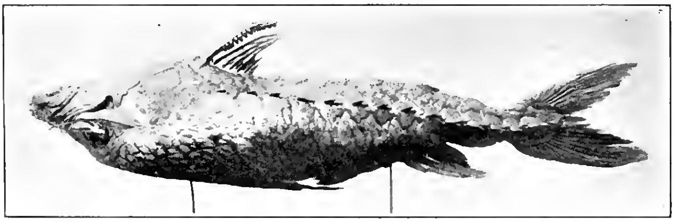
The great variety of South American fishes is due to the divergence in the types of characin, catfish, cichlid and pœcilid.

3. *Paucity of Middle American Fauna.*

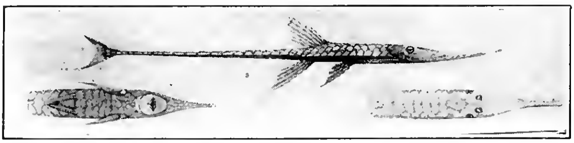
The fresh-water fauna of middle America is poor. No river excepting the Lerma harbors as many as 50 species. The genera south of the isthmus of Tehuantepec are practically all South American with the addition of pœcilids.



6. *Platystomatichthys sturio* KNER. ONE OF THE GIANT CATFISHES.



7. A NEW *Plecostomus*, ONE OF THE MAILED CATFISHES.



8. A *Farlowella*, ONE OF THE SLENDEREST OF THE MAILED CATFISHES.

4. *The Isolation of the Fauna of the Mexican Plateau.*

The Lerma, draining the Mexican plateau, harbors an old fauna. Only three of its fifty-four species have been taken in any other river basin. Eight of its twenty-one genera are peculiar to it.

5. *Paucity of the Pacific Slope Fauna.*

From the Pacific slope of South America, south of Panama and north of Chile, but 55 species of fresh-water fishes have been reported. This condition is not unlike the condition in North America, for more species may be obtained from a single favorable brook in the Mississippi valley than are found on our entire Pacific slope, from San Diego to Alaska.

Fifteen out of the 55 species are also found on the Atlantic slope, and the others, with three exceptions, belong to genera of wide distribution on the Atlantic slope. None of the species would cause any surprise if found on the Atlantic slope.

6. *The Marine Character of the Titicacan Fauna.*

The fish fauna of Lake Titicaca, about as large as Lake Erie, consists of a catfish, *Pygidium rivulatum,* and several species of *Orestias,* a *Fundulus*-like pœcilid. The former belongs to a genus of mountain catfishes universally distributed in mountain streams of South America. It has succeeded in crossing all sorts of barriers, and has undoubtedly migrated into Lake Titicaca from the streams surrounding it. The genus *Orestias,* on the other hand, is confined to Lake Titicaca and the streams and lakes immediately surrounding it. The latter have doubtless received theirs from Lake Titicaca, which, on its part, could only have received them at the time it was an arm of the sea, in which its nearest relatives flourish.

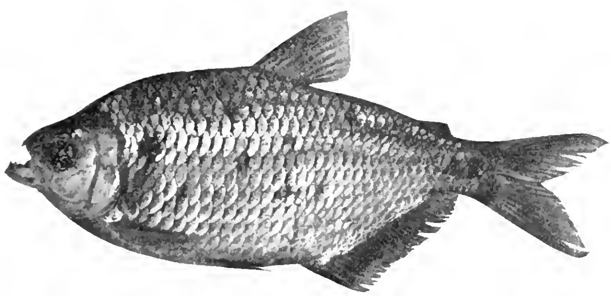
7. *The Patagonian Fauna.*

The interest in the Patagonian fresh-water fish fauna is entirely out of proportion to its diversity and centers largely in its origin. Only about twenty-five species of fishes are known to live or enter the fresh waters south of the line joining Valparaiso and Bahia Blanca. These few species fall, according to their origin, into four distinct groups.

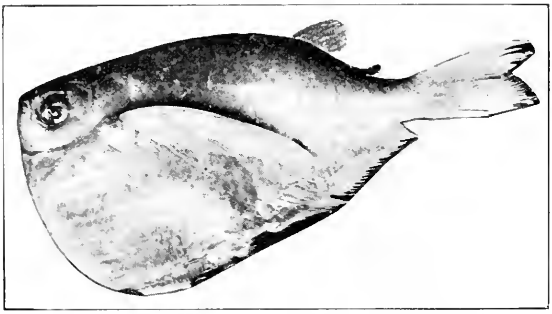
1. Immigrants from the sea (*a*) are in the process of acclimatization (species of *Menidia* and *Atherinichthys*), or (*b*) may be looked upon as long established (species of *Percichthys* and *Percilia*). Members of (*a*) are found in all the rivers; members of (*b*) are found in the north chiefly, but reach the Santa Cruz.

2. Immigrants from the fresh waters on the north; a very small overflow from the extremely rich fauna to the north and still retaining their generic affinity with the northern forms. Here belong the species of the genera *Cheirodon* and *Astyanax,* which are very widely distributed in tropical South America and are not known to extend much south of the Rio Negro.

3. Autochthons or of doubtful origin. Here belongs the highly



9. *Astyanax bimaculatus* L. A Characin found everywhere in Tropical South America, from Panama to Buenos Ayres east of the Andes, close relatives existed in the early tertiary. This photograph of a specimen from Trinidad.*



10. *Gasteropelecus stellatus* KNER, AN EXTREMELY SWELL CHARACIN. This is connected by many intermediate forms with normal-shaped species.

interesting *Diplomyste,* which is found on the northern border of Patagonia, but is not a derivative of the tropical American fauna. It is a relict of the original catfishes, in which the maxillary is still functional as a tooth bearer. Here belongs also *Nematogenys,* a catfish related to *Pygidium.* Like the members of group 2, these species are confined to the northern fringe of the Patagonian area.

4. There remain unaccounted for the members of the Aplochitonidæ, Galaxiidæ and Petromyzontidæ, chiefly of southern Patagonia.

Of the Aplochitonidæ there are two genera, *Aplochiton,* with an undetermined number of species in the Patagonian region, and *Prototroctes,* with three species, one in Queensland, one in South Australia and one in New Zealand.

Of the Galaxiidæ there are two genera, *Neochanna* (*apoda*) from New Zealand, where it frequently burrows in damp clay away from water, and *Galaxias,* with about 30 species, from New Zealand, New South Wales, South Australia, Tasmania, Cape of Good Hope, southern South America and the Falkland Islands. The Petromyzontidæ are found in all temperate fresh waters and seas in both the northern and southern hemispheres.

The distribution of the two former families is of interest in connection with the theory of a former antarctic continent connecting the land masses in which they are found. In favor of a former land connection it may be argued, and with justice, that while these species descend to the sea, the probability that any pair of individuals should migrate from Cape Horn to New Zealand, or *vice versa,* is highly improbable. (This objection loses some weight if they spawn in the sea, as is reported.) There are no intermediate places that might be colonized and serve as new centers of distribution. It may further be urged that these species could readily have been distributed to their present homes by migration from stream to stream along a continuous coast line or on a land-wave moving from one place to another. An obvious objection comes from the paucity of the forms with this peculiar distribution. If there was a continental mass connecting South America with New Zealand and Australia fit to be inhabited by fishes, there must have been an abundant and diverse fish fauna which has disappeared. If the antarctic continent depended entirely for its existence on the evidence from the distribution of the fresh-water fishes, its existence would be very highly theoretical and precarious.

However, the evidence from other sources of a former land connection has become conclusive, and I am of the opinion that during the submergence of large parts of Patagonia during the late Pliocene the formerly abundant fresh-water fauna became exterminated, with the exception of those that were indifferently fresh-water or marine.

The Petromyzontidæ offer still another difficulty. There is no place on the American continents between the Mexican plateau and Central Chile that harbors any species of the family. The northern and southern species belong to distinct genera. At least two of the South American genera are peculiar while two others are found in Australia and New Zealand.

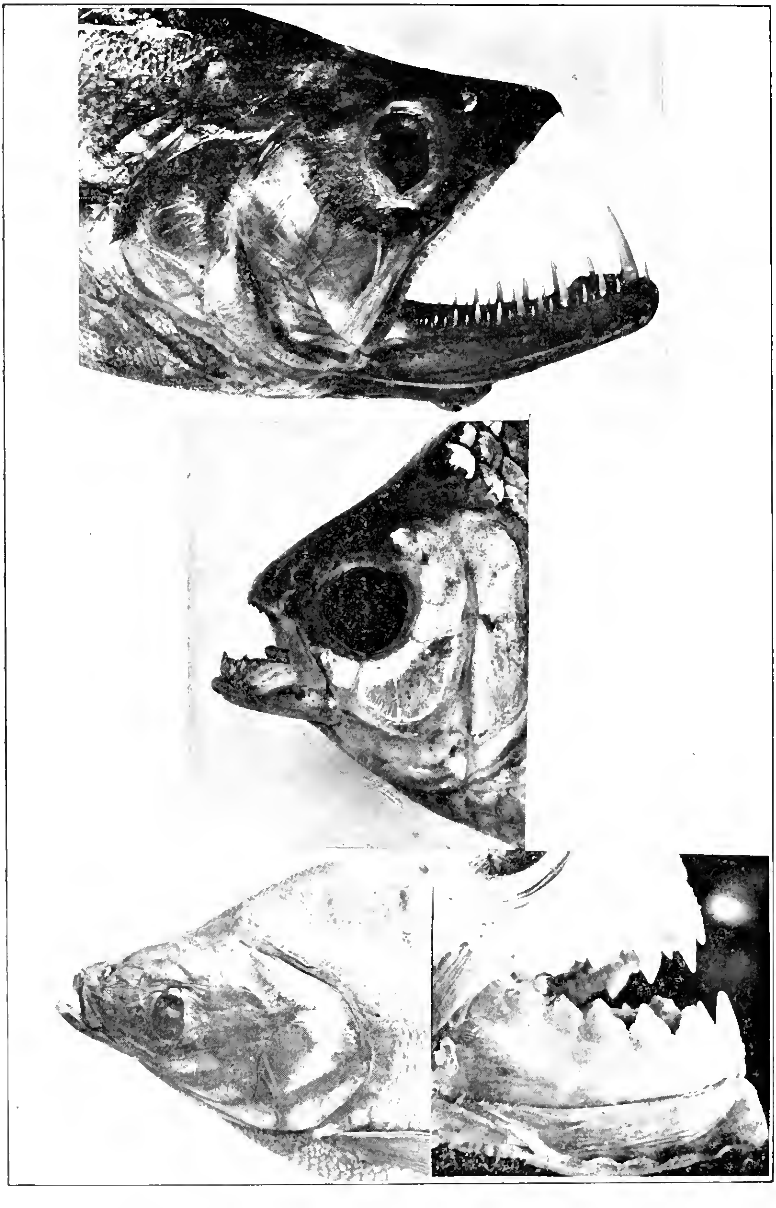
8. *The Similarity of the Tropical American to the Tropical African Fauna and the Necessity of and Evidence for a Former Land Connection between Africa and South America.*

North America has not contributed a single element to the fresh-water fish fauna of South America. Two prominent South American families, the Characinidæ and the Cichlidæ, have representatives as far north as the Rio Grande basin, and one of these has succeeded in crossing over into Cuba, evidently from Yucatan; on the other hand, several members of the North American fauna have representatives as far south as the Isthmus of Tehuantepec. The North American fauna is entirely distinct from the tropical American fauna.

But four genera of fresh-water fishes of South America north of Patagonia are found in any other continent than North America. These are *Synbranchus*, *Agonostomus*, *Cotylopus* and *Fundulus*. The first found also in brackish water, the second belonging to the marine family, Mugilidæ, and the others to the Pœciliidæ. *Synbranchus* is found in India, *Agonostomus* in middle America, the West Indies, northern South America and New Zealand, Australia, Celebes, Mauritius and Comoro Islands. There is no reason why *Agonostomus* may not have been independently evolved in the South Sea and in America from marine Mugilids. *Cotylopus* is found in Central America and Reunion and *Fundulus* in America and Europe.

It is possible that *Pimelodus* is found in Africa and *Pseudauchenipterus* in Madagascar. Both are found in South America.

Africa and South America have two groups of families in common. The first group comprises the Serranidæ, Sciænidæ, Mugilidæ and Tetraodontidæ.



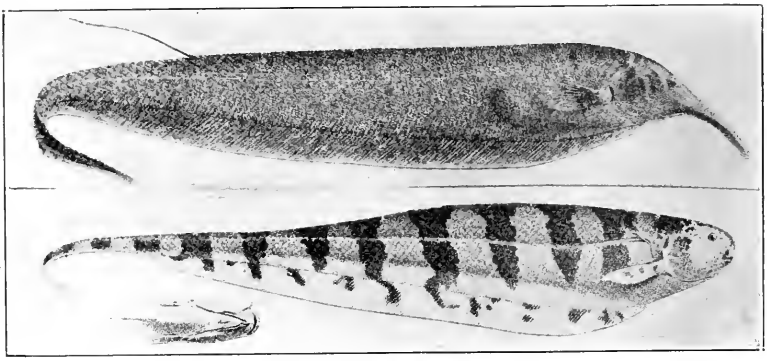
11. ADAPTIVE RADIATION IN THE CHARACINIDÆ. The central figure of *Astyanax bimaclatus* with notched teeth probably represents the more primitive condition. The lower left-hand figure represents *Anodus latior* with no teeth and a very long alimentary canal, a mud eater. The lower right-hand figure represents the scissor-like jaw and teeth of *Serrasalmo humeralis* whose relatives have been repeatedly reported to have killed bathers before they could reach shore after being attacked. The upper figure represents *Raphiodon vulpinus* Spix which has reached the extreme in conical teeth, the large canines protruding above when the jaws are closed. The over 100 South American genera and 500 species of this family offer pretty complete series from the center to the extremes with many lateral branches.

These are all marine families, some of which have also developed fresh-water forms in Europe and North America as well as in South America. The fresh-water forms of South America and Africa are local adaptations of marine families that require no change in the present condition to account for their origin.

The second group comprises the Lepidosirenidæ, Osteoglossidæ, Siluridæ, Characinidæ, Pœciliidæ and Cichlidæ. Of these the Lepidosirenidæ are relicts of a former widely distributed group, and it requires no land connection to satisfactorily account for their presence in Africa and South America. The Pœciliidæ live indifferently in marine, brackish water or fresh water. They reach their maximum development in the fresh waters of Mexico and Central America. The marine species are found along the shores, not at sea, and there is, therefore, at present, no known means of getting them from the American to the African shore. Nevertheless, *Fundulus* is found on both sides of the Atlantic, and there must have been an intermigration much more recent than the youngest possible land connection between Africa and South America, or else there has been a very long persistence of this type. A land connection, while not absolutely required for this family, would be very convenient.

The Siluridæ are in part marine. All of the South American forms of Siluridæ can be derived from the marine Tachisurinæ, and the same is probably true of the American members of the family. Furthermore, the catfishes are found in North America, Europe and Asia and have been recorded in North America from the Tertiary. A land connection between Africa and South America is, therefore, not absolutely required to account for their presence in both continents, though, as in the case of the Pœciliidæ, such a connection would be very convenient.

The Cichlidæ and Characinidæ are abundant in tropical America and in Africa, a few species of Cichlidæ being also found in India. There is no known means by which these two forms could have crossed the existing gap between Africa and South America. There has been no exchange of species in recent times, for there is no species or genus common to the two continents. The South American and African elements of these two families must have been derived from some intermediate land mass or must have gone from one continent to the other over a land bridge. That this connection, whatever it was, must have been obliterated before the tertiary, is evidenced by the facts that the tertiary deposits of Taubaté and Parana show existing genera and that there are many South American types, as the Gymnotidæ, Electrophoridæ, Bunocephalidæ, Loricariidæ, Argiidæ, Pygidiidæ, Callichthyidæ, Hypophthalmidæ and others not found in Africa that have all



arisen in South America from the Characinidæ and Siluridæ since the separation of the two continents.

Similarly, other families found in Africa and not in South America have either arisen in Africa since that time or have immigrated from the east.

A land connection, whether a land bridge, intermediate continent or land wave, between the two continents is imperative. This land connection must have existed before the origin of existing genera and before many of the existing families.

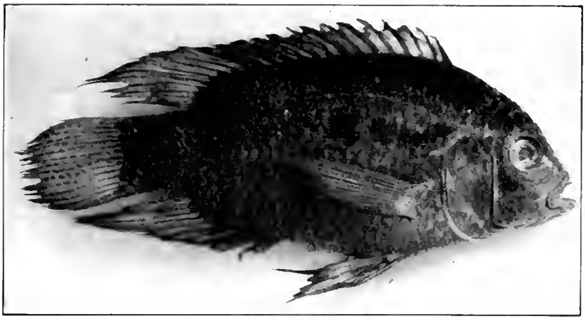
B. *Conclusions and Bird's-eye View of the Problems.*

America, south of the Tropic of Cancer, contains four (or five) distinct faunas. These faunas are the Transition, the Mexican, the South American and the Patagonian.

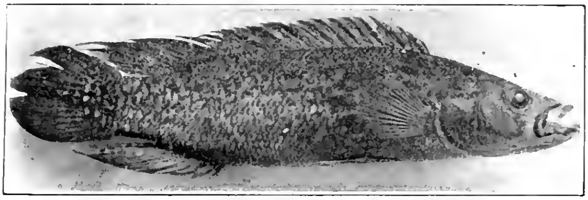
The northernmost, or Transition fauna, is characterized largely by instrusive elements from both the north and the south. It is found on the Atlantic slope from the tropic to the Isthmus of Tehuantepec and on the Pacific slope of this Isthmus.

12 MEMBERS OF THE GYMNOTIDÆ. *a*, *Sternarchorhynchus curvirostris* (Boulenger); *b*, *Steatogenys elegans* (Steindachner); *c*, *Sternarchus brasiliensis* (Reinhardt); *d*, *Eigenmannia virescens* (Valenciennes); *e*, *Giton fasciatus* (Pallas); *f*, *Rhamphichthys marmoratus* (Castelnau).

The Mexican fauna is unique, and occupies a narrow strip inclu-



13. *Cichlasoma bimaculatum* L.



14. *Crenicichla saxatilis* L. TWO MEMBERS OF THE CICHLIDÆ, of which there are about 150 known species between the borders of the United States and Patagonia.

ding the valley of the City of Mexico and the Lerma basin draining to the west, and the Rio San Juan, a tributary of the Panuco, draining to the east. While containing intrusive elements from the north, it contains none from the south, and its fauna is so distinct from either that there is slight hesitation in considering it as equivalent to the American, South American and Patagonian faunas.

The third, the South American fauna, is sharply divisible into the Brazilian and Andean. The Brazilian occupies the rivers from Southern Mexico to Buenos Aires and from Para to Callao, exclusive of the high Andes. This fauna is the richest in species in the world. From this region about ten per cent. of all the known fishes have been recorded. The Andean, from 3,000 to 5,000 feet and over above sea-level, while possessing some forms in common with the Brazilian, is quite distinct. The species inhabiting this region would cause surprise if found at Manaos: those of the Pacific slope would not.

The Patagonian fauna is among the poorest in the world. It occupies the Rio Negro basin, and everything lying south of it and a line joining it with Valparaiso. Its fauna has been considered in detail.

For convenience these faunal areas may be enumerated as the following 'regions' of unequal value. (1) Transition. (2) Mexican. (3) Brazilian. (4) Andean. (5) Patagonian. I am not sure but that the Titicacan basin constitutes a 'region' distinct from the Andean north of Titicaca.

The origin and distribution of the fresh-water fishes of tropical South America have come about as follows: In the earliest tertiary tropical America consisted of two land areas, Archiguiana and Archamazona, separated by the lower valley of the Amazon, which was still submerged. There was a land mass, Helenis, between Africa and South America, possibly in contact with Guiana in South America and some point in tropical Africa.[1]

This land mass was inhabited, among other things, by Lepidosirenidæ, Pœciliidæ, Characinidæ, Cichlidæ and Siluridæ. This land-mass sank beneath the surface of the ocean, forcing the fauna in two directions, towards Africa and towards South America, exterminating all types not moved to the east or the west. From these two rudiments have developed the present diverse faunas of Africa and South America, each reinforced by intrusives from the ocean and neighboring land areas and by autochthonous development within its own border. The one fauna can not be said to have been derived directly from the other.

The connection between Africa and South America existed before the origin of present genera and even before the origin of some of the present subfamilies and families, some time before the earlier tertiary. There has never been any exchange between Africa and South America since that time.[2] There must have been an intimate connection between these two continents, for there is no evidence such as identical species or genera on the two coasts to indicate an occasional or accidental exchange of types across the Atlantic since the formation of existing genera, therefore such an interchange across the ocean probably never took place. The east Brazilian land mass south of the Amazon (Archamazona) must have become stocked from the western end of Helenis, or Archiguiana, very early, for it contains many genera peculiar to the region, indicating a long separation, and tertiary fresh-water deposits in this area contain existing genera of fresh-water fishes.

When, later, the Cordilleras arose out of the ocean at a distance from Archiguiana and Archamazona too great to be traversed by colonists from them, their developing streams and arms of the sea, connected with brackish, and, later, fresh-water lakes, all became populated with marine types. In the north where they later came into competition with immigrants from Archiguiana most of them were exterminated with the continued elevation of the land. On the south, which was not, or not so easily, reached by immigrants, *Orestias, Gastropterus* and *Protistius* remain in the high Cordilleras of southern Peru as relicts of these marine species. Later, as the distance between the

[1] This paragraph is an outline of part of von Ihering's Archiplata-Archhelenis theory.

[2] There has been a remarkable parallelism in the evolution of genera of cichlids, characins and catfishes on the two continents that I hope to take up in another place.

Cordilleras and Archiguiana was reduced, these mountain streams, especially those of Ecuador and Colombia, became populated by stragglers or accidental visitors from the land areas to the east. These in their turn, with the elevation of the Andes, became modified and gave rise to the genera now peculiar to both slopes of the high Andes, *Pygidium, Eremophilus, Chætostomus, Arges, Cyclopium, Astroblepus,* etc.

With the further elevation of the Cordilleras into a continuous barrier and the formation of the Orinoco, Amazon and La Plata valleys through elevation and the débris brought from the land masses and the development of the enormous fresh-water system occupying these valleys, this system, particularly the Amazon, became progressively colonized from the older land areas and became the center of unparalleled adaptive radiation and a new center for distribution which it has remained to the present time. The comparatively few types inhabiting the old eastern land masses found themselves in possession of a continent and diverged in every conceivable direction. I have hinted at this divergence in a recent article (*Biol. Bull.,* VIII., pp. 59–66). It will be considered in detail in a forthcoming monograph of the characins[3] of America.

From the Amazon species moved in all directions till they met barriers of one sort or another. The Pacific slope fauna is derived to a very large extent from this later divergent migration over the Isthmus of Panama and through the valley of the Atrato, between the western and coast Cordilleras of Colombia.[4] Others possibly crossed over the

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[3] The characins are a family of fresh-water fishes that, in America, range from the border of the United States to some distance south of Buenos Aires. They form about one third of the entire South American fresh-water fauna, and have diverged in adaptation to diverse food, diverse habitat and diverse enemies to fill nearly every niche open to fishes. The ends of the three lines of adaptation to different food give us mud-eating forms, with long intestinal tract and no teeth; flesh-eaters with shear-like teeth, that make bathing dangerous to life and that cut their way out of nets; and conical-toothed forms, with sharp, needle-like teeth and comparatively huge fangs. Greater diversity could scarcely be imagined, and one is lead to suspect that some of the forms are over-adapted. In their divergence in form they have reached almost every conceivable shape. . . .

Diverging among themselves as has been noted above, they have approached, or paralleled many members of the diverse families of North American fresh-water fishes. Our shads and fresh-water herrings have their counterparts in *Elopomorphus, Potamorhina* and *Psectrogaster;* our salmon are paralleled by *Salminis* and *Catabasis;* our minnows are paralleled by *Tetragonopterus* and its relatives. It will take but a slight flight of the imagination to detect the striking similarity of some of the Hydrocyninæ to our gar pikes; our mullets are duplicated by *Prochilodus;* our top-minnows are mimicked by *Nannostomus,* and even our festive darters are duplicated by a member of this most remarkable family, *Characidium fasciatum.*

[4] See SCIENCE, N. S., XXII., pp. 18–20.

Andes east of Guayaquil before the Andes reached their present height. The Pacific slope fauna is less different from the Amazon fauna than that of the coastwise streams of Minas, if the number of peculiar genera is used as a measure of difference. The origin of the fauna of the plateau of Mexico is a separate subject.

The points of strategic importance for ichthyic chorology in South America are, therefore: (*a*) western Colombia and Panama; (*b*) Guayaquil to the Amazon, across the Andes; (*c*) the tableland of Guiana, Archiguiana; (*d*) the Rio San Francisco, with the Ria Parahyba and the headwaters of the Tieté and Rio Grande, in Archamazona; and (*e*) the area between the Rio Negro and the La Plata. It is these regions which will yield the richest scientific harvest to any museum undertaking South American exploration.

FACTS ABOUT NOSTRUMS

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THE quantity of secret and semi-secret drug mixtures consumed by the American people is enormous. While it is impossible to determine accurately the extent of the custom of self-medication a recent writer has estimated that over $100,000,000 is expended annually for so-called 'patent medicines.' The investigation of the causes which have led to the growth of this business affords an interesting study of human nature and also throws a light upon the subject of the effect on the health of the community. Since time was mankind has desired when sick the advice of some one who has devoted especial attention to the subject of relieving human suffering, and while here and there are scattered over the land adherents to various faddists, who, on account of religious beliefs or credence in some peculiar theory of health, have ceased to consult doctors, yet the overwhelming majority of the people still believe in the usefulness of the medical profession as well as of drugs.

The two motives which most commonly lead to experimentation with advertised nostrums are the desire to avoid calling in a physician and to save thereby the doctor's fee, and the hope that better results may be achieved than are offered by the regular medical profession. Occasionally, as in unsettled districts, the impossibility of obtaining medical advice forces 'home treatment,' but this condition is so infrequent that it may be practically disregarded.

In the majority of instances it is the indisposition to send for the doctor which explains the self-dosing, not always from the desire to save money, but at times from a sense of shame in annoying a busy man with some trivial complaint which the patient believes he can treat himself with equal benefit. This feeling covers the use of a large number of the less objectionable proprietary remedies such as the laxatives, but is also the predominant factor in the employment of the most diabolical of them all, the 'soothing syrups,' with which hundreds of non-thinking mothers are poisoning their children. One of the dangers, which attend all self-medication but apply with especial force to the habit of relieving seemingly trivial complaints, is that some serious trouble, still in its formative stage when proper treatment is most efficacious, is neglected until the damage wrought becomes irreparable. For example, a man is taken with what he believes to be an ordinary 'stomach-ache,' due to indigestion, and buys some 'pain-killer' or 'dyspepsia tablet' with which he experiments on himself for two or three days; the physician called too late finds appendicitis gone on to a stage perhaps where a fatal issue is unavoidable. Again, in the spring of the year a feeling of languor is diagnosed by the doctor-patient as 'spring fever,' for which he doses himself religiously with some stimulating 'blood purifier,' while the real nature of the case may be a beginning typhoid fever. The list of such conditions which may and do occur might be drawn out *ad infinitum,* but enough has been said to show the great fundamental objection to all nostrums.

This danger, it must be confessed, however, is after all a comparatively remote one. The great imminent peril which threatens the life and health of the nation lies in the fact that a large number of these remedies contain poisonous and habit-forming ingredients. The most horrible instance of this is the 'soothing syrups.' These are universally loaded down with morphine. The immediate deaths which have followed an overdose of some opium-containing 'soothing syrup' are numerous enough, but the thought of the hundreds of children condemned from the cradle to a life of invalidism, to which the grave is preferable, by the formation of a morphine habit from which the delicate nervous system is never able to recuperate, is horrible. The poor ignorant mother is usually not to blame, but the devilishness of the nostrum vender who deliberately sets out to poison helpless infants puts him below the murderer in criminal immorality, and the supineness of a government which permits such crime to go unpunished must bring a blush of shame to the face of every thinking citizen.

Another frequent offender of this class is the 'cough syrup' or 'pectoral.' These nearly all contain either opium or some closely allied drug. Those of the headache powders and other remedies for the relief of pain which do not contain opium almost without exception are preparations of acetanilid, a substance derived from coal tar, which, although perhaps not so dangerous as morphine, produces an insidious weakening of the heart when used repeatedly, and whose victims number into the thousands.

Those who employ patent medicines from the second motive mentioned, that is, with the hope of obtaining better results than are promised by the regular medical profession, are naturally found chiefly among the less educated classes of society. To an intelligent mind it is evidently improbable that an untrained observer whose interests are purely commercial should know of some remedy of great value which generations of devoted physicians and scientists had failed to discover. The claims made by this group of nostrum mongers are so palpably impossible as to be ridiculous to all thinking men. Yet it is surprising to find how many persons of presumable intelligence, driven by the desperation of an incurable disease grasp at this frail straw in the hope of being rescued from untimely death. Such are found especially among cases of consumption, cancer, spinal disease or other similar chronic complaints whose outlook is unfavorable. Many of the nostrums belonging to this class are quite inert, while others contain opiates or stimulants which give temporary relief from symptoms but only hasten the end.

The question must present itself most forcibly, if the statements outlined above are true, how does it come that such a large body of the people continue to use these irrational remedies? This question is usually answered by attributing the results to 'shrewd advertising.' If shrewdness is synonymous with falsehood and blackmail the answer is correct. While it is true that an enormous amount of money is spent in advertising, yet back of all these advertisements is a mass of deceit which in any other business would prove ruinous.

It is necessary to digress for a moment to obtain a comprehension of the factors which have made successful commercial methods which under ordinary circumstances would mean certain failure. All patent medicines, with a few exceptions, as the laxatives, may be divided into two classes, the inert and the dangerous. The harmful remedies which are employed are usually either opium, cocaine, alcohol or acetanilid. All of these are drugs whose use is liable to lead to a craving for more. It is evident that if Peruna once starts an alcohol habit, or if Bull's 'Cough syrup' makes an opium fiend, or Birney's 'Catarrh Cure,' a cocaine habitué, the future sale of that remedy is assured. After once being persuaded to consume the first bottle of the deadly nostrum the financial and moral wreck of the victim is an easy matter. It is asserted that so widespread has become the use of some of these remedies that cures are now being advertised for the relief of the Peruna habit. With the inert nostrum the conditions are somewhat different. These depend for their prosperity upon the large number of credulous persons from among whom new customers may be obtained when some old customer awakes to the fact that, in the language of the college youth, 'he has been stung.'

It is clear that the task of the purveyors of inert frauds is a more difficult one than that of the vender of habit-forming poisons. But the methods of procuring new customers is essentially the same in each instance. To obtain fresh victims there is no depth of immorality to which the manufacturer of the nostrum will not stoop. The lies are of manifold variety, but of a few classic types.

The first of these, which may be denominated as the lie simple, is the extravagant claim to cure all sorts of conditions, based simply on the statement of the owner of the drug. Sometimes these are fortified by offer of 'money back if not satisfied' or one hundred dollars, or a thousand, or a million—it makes no difference, since it is never paid—'for a case which can not be cured,' etc. As an example of the sincerity of these offers an illuminating correspondence is quoted from the *Journal of the American Medical Association*, as follows:

April 21st, 1906.

Drs. Brown and Lenox, Rogers, Ark., send us an account of a case of catarrh which was not cured by Hall's Catarrh Cure. The patient, Mr. Robert Parks, consulted these physicians for catarrh and stated that he had just finished his twenty-sixth bottle of Hall's Catarrh Cure, but that instead of being benefited he was worse. Mr. Parks wrote to the Cheney Medicine Company, the maker of Hall's Catarrh Cure, giving his experience, and asking the firm to pay $100.00 in accordance with the advertisements: "$100.00 for any case of catarrh which it will not cure" or to refund the money he had paid.

The following is a copy of a letter which he received in reply:

Toledo, Ohio, March 30th, 1906.

Robert Park, Rogers, Ark.

Dear Sir: Yours of recent date received and in reply will say, as we have already said, that many cases require much more than you have taken for a cure, and as this is the case and Hall's Catarrh Cure is not placed on the market on the 'No cure, no pay' plan, we would not feel at all justified in refunding the money paid for this trial of the medicine. Will further say that you have failed to state much regarding your disease, symptoms of same, of how long standing, symptoms of the action of the medicine, etc. Had we more information concerning your case, we might have been able to make some helpful suggestions regarding the treatment."

Yours very truly,

F. J. Cheney & Co.

A. G. A.

The second type of falsehood which is used by these manufacturers is the testimonial lie. Some obscure citizen who has been rescued from some imaginary complaint spills his gratitude to the nostrum manufacturer in a lurid if ungrammatical epistle. Sometimes, however, it is not an obscure citizen, but a prominent one, a senator, or an admiral of the United States Navy or some one equally before the public eye. Some of these testimonials are absolute fabrications. The boldness with which nostrum venders manufacture evidence is astonishing, and only comprehensible in view of the fact that there is usually no legal punishment. Some years ago, Duffy's Malt Whiskey Company stated in their advertisements that it was recommended in consumption by Dr. ———, one of the most prominent physicians of Philadelphia, when as a matter of fact he had never tasted it nor prescribed it; but the courts offered no redress and the only means of cleansing his reputation was an advertisement in the daily papers. Some of the testimonials are bought. (There is a firm in this country which is engaged in the sale of testimonials to nostrum manufacturers.) The following circular speaks for itself.

As you are aware, we have your testimonial to our remedy. It has been some time since we have heard from you, and so we thought best to make inquiry as to your present state of health, and whether you still occasionally make use of Peruna. We also want to make quite sure that we have your present street address correctly, and that you are making favorable answers to such letters of inquiry which your testimonial may occasion. Remember that we allow twenty-five cents for each letter of inquiry. You have only to send the letter you receive, together with a copy of your reply to same, and we will forward you twenty-five cents for each pair of letters. We hope you are still a friend of Peruna, and that our continued use of your testimonial will be agreeable to you. We are inclosing stamped envelope for reply.

Very sincerely yours,

THE PERUNA DRUG MANUFACTURING CO.,

PER CARR.

It would seem time for the law to intervene to stop this noxious traffic. Owing to recent agitation in certain magazines some effort has been made to restrict it, but it has met with vigorous opposition from a venal lobby. Those interested in the business argue that this is a free country and that each one must be allowed to use his own judgment as to what is harmful or beneficial. Such sophistry would be laughable if it were not used with such deplorable results. In almost every state of the union the practise of medicine is rigidly controlled. The applicant must show not only proof of medical education, but must pass an examination given by the state, before he is licensed to practise. As sensible an argument would it be to say that every one has a right to practise medicine and that each one must use his common sense in choosing a doctor who is educated. In many states of the union there are laws regulating the adulteration of foods. In but one or two states are there laws preventing the sale of deadly poisons in the form of patent medicines.

Government is for the purpose of protecting society from the depredation of persons whose moral intuitions are below the average of the people in general. We hang murderers in order that they may find no further victims; we lock up thieves that our property may remain safe; we allow patent-medicine monsters to murder and to steal without restraint. The proprietors of these nostrums are to be classed as moral perverts, for while they may deceive the public with various statements concerning the value of their remedies, they themselves are in no wise deceived. Being so, it becomes the duty of our legislative bodies to protect the community. The general public does not and can not be expected to separate the truth from the falsehood about the value of unknown drugs. When the poor, uneducated, epileptic whose mind has been enfeebled by disease, reads in a respectable paper an advertisement backed with some testimonial, he can not know that the testimonial is false and that the claims are absolutely impossible, but readily becomes the dupe of the charlatan, throwing away both money and life in search of the 'Will-o'-the-wisp.'

There is now pending before the United States legislature a bill which the nostrum dealers cry out is a terrible crime against personal liberty and a ruination of a great business. And what is the terrible proviso which so frightens those engaged in patent medicine business? Simply that all proprietary remedies containing opium, cocaine or other poisonous ingredient shall state upon the label the exact amount of the poisonous ingredient present; as feeble and conservative a measure for this great evil as one could well imagine.

With any other measure of similar importance before congress the newspapers, which are the great voice of the people, would cry in such a tremendous chorus for relief that no legislator would dare to hesitate to pass the bill. But the silence of the newspapers and magazines, with a few notable exceptions, has been bought through the advertising columns. In this morning's paper I find an advertisement for Hood's Sarsaparilla which occupies space value, according to the published rates of the paper, of seventy-five dollars; Doctor Pierce occupies sixty-five dollars' worth; Cuticura is satisfied with thirty dollars' worth, and other advertisements in similar quantities bring up the day's total to $240. This does not include the smaller notices of drugs among the personal columns and small classifications. In the evening paper Duffy's Malt Whiskey has a prominent place with the picture of a 'grand old patriarch' who was enabled to reach the age of one hundred and four years through the constant use of this liquor, while one tenth of the entire issue is advertisements of secret remedies. Receiving as they do $900,000 a year apiece from this business, is it any wonder that the newspapers are disposed to keep silent concerning the evil of it? The mouthpiece of the nation is stopped with gold; let the people, therefore, speak directly and bid their legislators save the ignorant and the innocent from the voracity of the conscienceless degenerates who are robbing them of health and money at the same time.

THE TIMES AND PLACES OF EARTHQUAKES[1]

By Professor H. H. TURNER, F.R.S.,
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THE occurrence of several disastrous earthquakes and eruptions during the last few months inevitably suggests the question whether all these events may not have a common and determinable origin. To avert any of these disasters, even to modify them in the slightest degree, may be entirely hopeless; but the vaguest foreknowledge of their probable occurrence might be of untold value in saving life and property. Has modern research obtained any clues which enable predictions to be made, or promise that prediction may be possible in the near future? It must be frankly admitted that as yet our knowledge is so slight as to have no commercial value; but still, there are one or two clues in the hands of those working at the subject which may ultimately lead them to more directly useful knowledge. We have learnt something of the regions where earthquakes occur, and something of the times when we may specially expect them; and, though the something is in each case a very little, the magnitude of the issues involved lends it interest.

Systematic observation of earthquakes is only about a quarter of a century old, and for fairly complete records of all the shocks occurring in different parts of the globe we can date only from 1892. Before that date information could only be collected on the spot, and was thus frequently lost; but it was realized about 1890 that a series of earthquake observatories, with delicate instruments, could obtain records of shocks in any quarter of the globe, and identify the spot with certainty, even if there were no witnesses of the actual occurrence. From the records of these observatories it appears that there are every year some 30,000 minor shocks of earthquake in different localities, but of these only 60 are 'world-shaking' and observable from a great distance. Such numbers indicate immediately that, from one point of view, the San Francisco earthquake can not be regarded as exceptional; it was only one event out of 60 per annum. What rendered it disastrous was the existence of a great town in the shaken locality. But was the neighborhood known to be a dangerous one? Was it at any rate, suspected, so that the building of a great city there was an error of judgment? and is it advisable to rebuild the city in the same place? These are

[1] From the London *Times*.

questions of the gravest importance; and it is well worth while to review the little knowledge already accumulated with the utmost care to see whether it will give us even provisional answers to them.

Professor Milne, in the tenth report of the British Association committee, refers the 'world-shaking' earthquakes observed in the six years 1899–1905 to thirteen great earthquake regions, designated by the first thirteen letters of the alphabet. Three of these, I, J and L, are responsible for only five, three and two shocks respectively, and are thus of small importance compared with the others, which average about forty shocks each. Excluding them for the present, the remaining ten regions lie approximately in two rings on the earth's surface, a configuration which is most strikingly apparent when the regions are marked on a globe. The more important ring includes the following seven regions: A (Alaskan coast), B (Californian coast), C (West Indies), D (Chilian coast), M (South of New Zealand), F (Krakatoa region), E (Japan). Its center is among the conspicuous group of islands which includes Tahiti, and the radius of the ring is about 65 degrees. The other ring has its center at the opposite point of the earth, which is in the Sahara desert; and at a radius of 50 degrees from this center lie regions G (between India and Madagascar), H (the Azores) and K (Tashkend). Now, this is not merely a convenient geographical summary, but a physical fact of vital importance, according to recent researches by Professor Jeans. In a remarkable paper read before the Royal Society in 1903 he gave reasons for believing that the earth is by no means a sphere or a spheroid, as we have been accustomed to think, but is of a pear-shape. Under gravitational stress it is continually approaching the spheroidal form—the pear is being crushed into a sphere by its own attraction; and the result is a series of earthquakes. These naturally occur in the weakest places, and if any one will experiment in crushing a pear towards a spherical shape, or even draw a diagram and consider where the weakest points would be, the reasons for the existence of two rings of greatest weakness will readily suggest themselves. The ends of the pear are the centers of these rings, one in Africa, one in the Pacific; and when once this is pointed out, the pear-shape of the earth is, according to Professor Sollas, 'obvious to mere inspection; it is a geographical fact and not a speculation.' Professor Sollas is indeed responsible for the particular suggestion above sketched; for Professor Jeans had originally proposed a different axis, which he withdrew in favor of the obvious improvement. The confirmation of Professor Sollas's view from the distribution of earthquake centers is remarkable. It does not seem, however, quite certain which is the blunt end of the pear; it has been hitherto placed in Africa, but there seem to be several reasons for regarding

Africa as the stalk end. This point can not, however, be dealt with here. The important thing is that there seems to be a real reason for the occurrence of earthquakes in these particular regions, and that they will probably continue to occur there. Professor Jeans's conclusions have recently been examined by Lord Rayleigh, who announced at the Royal Society only a few weeks ago that he found them generally confirmed, and that we must regard our earth as at present in a state far from stable.

The lessons to be learnt from the distribution of earthquakes in space are accordingly tolerably plain in theory, though in practise we may not be able to take advantage of them. If we would be particularly safe from earthquakes, we must take up our abode near one of the ends of the pear—either in Africa or in the Pacific. There is also a region of safety between the two dangerous rings—in America generally, for instance, excluding the west, or in Siberia. But the dangerous regions include so vast and so valuable a part of the earth's surface that it is impracticable to leave them unoccupied. Moreover, our knowledge is as yet not specific enough. In the dangerous regions themselves, some parts are much more dangerous than others; for instance, Japan, which is reckoned above as a single region, can be divided into at least fifteen distinct seismic districts. As observations are accumulated we may be able to make similar partitions of the other regions. For the present the general attitude towards earthquakes will probably be similar to that towards other dangers, such as those of travels and voyages for instance; the risks must be incurred. We know that there are at times fatal tornadoes; but other interests are at stake, and we put to sea in the hope that none will occur during our voyage.

We come to the second point, the distribution of earthquakes in time. Are there seasons of special activity such as the recent occurrence of several disasters seems to suggest? Here our knowledge is slighter still, and the observed facts have not yet been coordinated by a mathematical investigation. Still there seems to be some evidence in support of the view that exceptional irregularities in the rotation of our earth may be responsible for an increased number of earthquakes at particular times. That the evidence is slight must be attributed to the shortness of the time during which it has been possible to obtain it, and not necessarily to inherent weakness in the evidence itself. The brevity of the earthquake record has been mentioned above; that of irregularities in the earth's rotation is longer; but the discovery that such irregularities existed was made only twenty years ago, though the phenomenon was then traced back through the old observations. The irregularities are systematic in character, and the law governing them is approximately known already; so that, if the presumed connection between them and earthquakes is confirmed, we may be able to predict periods of great earthquake frequency. Such periods would be in some respects analogous to the times of spring-tides. It is a familiar fact that at new and full moon the tides are much greater than when the moon is at the quarters. The reason is that we have two tide-raising bodies, the moon and the sun, which sometimes act in concert, and then we get large tides; sometimes in opposition, and then we get small tides. If the influence of these two bodies were more nearly equal, instead of the moon being so predominant a partner, we can imagine times when the tides would be barely perceptible. Similarly there are apparently two contributors to the variation in our earth's rotation, which sometimes act in unison and sometimes in opposition. They are more nearly equal in influence than are our moon and sun; and consequently there are times when these two contributors nearly balance one another and the axis of rotation remains almost steady. But in due time the contributors reinforce one another and the axis acquires a considerable 'wobble.' Each end of the axis then describes a curve composed of wide sweeps and sharp bends; and the evidence seems to be that at the sharp bends we are particularly liable to earthquakes. The exact statement of the case as given by Professor Milne in his Bakerian lecture, 'Recent Advances in Seismology,' delivered before the Royal Society, on March 22, last, is as follows:

> In a period of nearly thirteen years (1892 to 1904) I find records for at least 750 world-shaking earthquakes, which may be referred to three periods continuous with each other, and each two-tenths of a year or 73 days' duration. The first period occurred when the pole movement followed an approximately straight line or curve of large radius, the second equal period when it was undergoing deflection or following a path of short radius, and the third when the movement was similar to that of the first period. The numbers of earthquakes in each of these periods taken in the order named were 211, 307 and 232—that is to say, during the period when the change in direction of motion has been comparatively rapid the relief of seismic strain has not only been marked, but it has been localized along the junctions of land blocks and land plains where we should expect to find that the stress due to change in direction of motion was at a *maximum*. Until the magnitude of these induced stresses has been estimated it would be premature to assume that the frequency under consideration is directly due to change in direction of pole movement, it being quite as likely that both phenomena may result from a general cause.

It is eminently to be desired that a mathematical investigation of the point should be undertaken; but the difficulties are very great, and as yet no one has had the time and courage to attack them. It will be seen, then, that the seismologist is as yet not able to give forecasts of any commercial value, though he is by no means without hope of doing so.

There are, however, some lessons of immediate practical importance which have been learnt by seismological study; we may again quote from Professor Milne's Bakerian lecture:

> At the Imperial University of Tokio a platform was constructed which by means of powerful machinery could be made to reproduce earthquake motion of varying intensity. On this table large models of masonry, wood, and metal designed to resist expected seismic accelerations were tested. This table has been to the builders in Japan what a testing tank in a dockyard has been to constructors of large vessels. The ultimate result of these and other investigations has been to modify and extend the rules and formulæ of ordinary construction, and now in Japan, as opportunity presents itself, new types of structure are springing up. These have withstood violent shakings which have materially damaged ordinary types in the neighborhood. While much has thus been done to reduce the loss of life and property, the Japanese government, stimulated by the results of this experience, has been encouraged to extend its support to seismological investigations in general.
>
> In 1886 the chair of seismology was established at the Imperial University, and since 1892 there has been in existence a seismological investigation committee, which has already issued 70 quarto volumes. At the Central Meteorological Observatory in Tokio records are received from nearly 1,500 observing centers.

From these paragraphs it will be seen that there are questions which merit the close study of engineers and architects whose work lies in the dangerous regions, though but little attention has been paid to them except by that wonderful little people who have already taught us more than they learnt from us. It is some consolation, doubtless, to reflect that modern seismology owed its origin to Englishmen. It was the little community of Englishmen who were invited in 1880 to 'pitch their tents on the trembling soil of Japan,' in order to teach the Japanese something of western civilization, who began to study these earthquakes, and enlisted the sympathy of the Japanese government in the matter. The sequel in this case as in others suggests comparison, not perhaps between the disciple and his master, but between the treatments which they have received at the hands of the world in general and governments in particular. While seismological research has been stimulated and rewarded in Japan in the manner above indicated, Professor Milne's heroic exertions in England have met with very little recognition. Practically single-handed he has organized forty stations all over the world, where records are obtained, and has carried on the correspondence and clerical work necessary to keep them in communication and coordinate the records. Until recently the only assistance accorded him of any kind was a small grant of about £20 a year made by the British Association—all they could afford in view of the numerous claims on their small funds—which barely sufficed to buy the paper and chemicals for his own recording station at Shide.

Appeals for government aid have so far been fruitless; though recently one or two welcome private donations have been forthcoming.

It will, no doubt, be objected to this comparison that an important consideration has been omitted. Seismological questions are of urgent practical importance in Japan, but not in England. That is true, and we all hope that it may remain true; but our guarantee is not absolute. Whether the regions of danger are permanent or shifting is just one of the questions which the whole world is interested in answering, and which can be answered only by patient and laborious research. The British Isles are far from being in a specially safe region; in fact, they lie almost exactly on the smaller dangerous circle above-mentioned, through Tashkend, the Azores and the Indian region; and though earthquake activity seems to be at present limited to these three regions, and so far as it strays in our direction seems to find an outlet rather beyond us (in the region labeled J by Professor Milne, between Iceland and the North Cape, where three earthquakes were recorded in six years), we have no right to assume that this state of things is more than temporary.

During the last year or two, however, more has been done in Europe generally to follow the lead of Japan; international cooperation in seismological work has been organized in Germany; and though the adhesion of some important countries is not yet certain, owing to various difficulties which need not be noticed here, it is hoped that these may be smoothed away in time. If so we may look forward to a welcome strengthening of the corps of workers in seismology, though there is still more than enough work for them all to do.

VOLCANOS AND RADIOACTIVITY

By Major C. E. DUTTON, U. S. A.

ONE of the commonest and perhaps the most impressive of natural phenomena, the volcano, has hitherto been without any explanation of its cause, though it has been before the world a subject of theory for many centuries. The reason for this is quite apparent. We perceive the action of the volcano upon the surface and we know what it does. But the theater of its origin and the development of its energy are far below the surface of the ground, out of reach of inspection or direct observation. Human ingenuity has been baffled in its efforts to explain the phenomenon because of the want of observed facts and the impossibility of obtaining them. But while we are, and probably always shall be, unable to directly inspect the seat of origin of the volcano, there are certain inferences in connection with them which have attained a degree of probability which entitles us to use them as facts which may limit speculation and confine it within very narrow boundaries. I purpose to mention these inferences in order to see the general nature of the solution to which they point; for unless I am greatly mistaken, they will show us that we are close upon the verge of a solution.

1. The first fact to be mentioned is the solidity of the earth. It is so well known that I shall not dwell upon it and merely mention it in order to bring it, together with other facts, into the same series or group.

2. The second fact is the comparative smallness of the extravasated masses in any single volcanic eruption. In order to obtain an idea of the relative magnitude of an erupted mass, let us draw upon a true scale a segment of one degree of the earth's surface, of an arbitrary thickness—say thirty miles. Upon this segment draw the profile of Vesuvius. About a mile below the surface, beneath the volcano, draw the reservoir of lava, having the same mass as the volcano itself. It may have any thickness and any form, and is subject only to the condition that the capacity of it is the same as the mass of the erupted material. Now Vesuvius is built of I know not how many individual eruptions, but let us say one hundred, though I presume that there were, in reality, very many more. A single average eruption would be the hundredth part of the volume of this reservoir. But there are eruptions known which are many times greater than the average of those of Vesuvius. The largest known in the United States are in

the Snake River Valley, and while we are not in a position to compute with accuracy their dimensions, we can say with confidence that the volume of the largest of them does not exceed two cubic miles. The great eruption of the Skaptar Jokul, in Iceland, in the year 1783, was estimated by Dr. Thoroddson to have outpoured twelve or thirteen cubic kilometers, or three cubic miles of lava. The greatest eruption of which we have any estimate, and that is a very crude one, was at Tomboro, on the island of Sumbawa, which was estimated to have discharged about six cubic miles of lava. This estimate is regarded as very excessive.

On the same scale as before, these two eruptions are represented, and you perceive how insignificant they are in mass in comparison with the whole of the surrounding earth.

3. The third general fact is the repetitive nature of volcanic eruptions. A single outbreak with none following is an exceedingly rare phenomenon. Many eruptions, going often into the thousands, occur before the climax is reached and the decline of activity follows. The reason why a volcano, when its vent is once open, does not discharge all the material in its reservoir in one stupendous belch and then close up forever will be shortly brought up.

4. The next general fact, which we can not claim to be proven, but for which there is a growing mass of strong and highly concordant evidence, is that the seat of the reservoir is very shallow and never more than three miles deep. Very rarely is there any indication of its being more than two and one half miles deep, and it is certain that in many cases the depth is less than one mile. The indications are that most of the volcanic eruptions originate at depths between one mile and two and one half miles. The evidence of this is furnished by the earthquakes which almost always accompany them and which are associated with them in such a way as to leave no doubt or question that they are produced by the volcanic action. The radiation of the tremors of an earthquake from their source in the earth is governed by substantially the same law as sound. The intensity of these tremors where they reach the earth's surface varies in a manner which is dependent upon their depth of origin. In the discussion of the Charleston earthquake, I pointed out one method by which that depth can be approximately computed from the distribution of critical points of the surface intensity. The method has been sharply criticized by able seismologists as being liable to error through refraction of the rays of propagation through rocks and media of variable density. But I observe that all of them use that method with surprising consistency and satisfactory results.

The efficiency of this method depends mainly upon the accuracy with which the intensity can be estimated along a line radiating from the epicentrum. It often happens that the intensity is so much affected by the local nature of the soil and rocks that all estimates become so uncertain as to be very misleading, and all attempts to draw conclusions from them must be affected by large errors or may fail entirely. On the other hand, in many cases the results are safer and surer than would be supposed, and we are able to give a graphic representation of the curve of intensity which must be very near the truth. In general, when an earthquake is very strong at the epicenter and quickly fades out away from it, we can say with confidence that its centrum is very shallow. If the intensity fades out slowly and the quake is felt at great distances, we can rely upon its centrum being very deep. When, therefore, we have not the means of estimating the intensity at the critical points, if we have the means of estimating the maximum intensity of the quake and of knowing how far it is felt, we can still form, not, indeed, a precise or accurate estimate of its depth, but a roughly approximate one.

A qualification of the foregoing may be introduced here. The earthquake is no doubt the fracturing or sudden yielding of the rock masses immediately above the lava reservoir. We can only vaguely conjecture the distance which separates the zone of fracture from the zone of melting. But in no case could it be so great as a mile without making itself sensible in the greater depth of the quake. We must, however, increase slightly our estimate of the depth of the lava beyond the estimated depth of the quake.

We may now proceed to state the probable cause of volcanic eruptions. They are caused, I conceive, by a development of heat resulting from radioactivity in limited tracts at a depth of one to three—at the very utmost not over four—miles from the surface, which is sometimes sufficient to melt the rocks affected by it. The melting is gradual, and when a sufficient quantity is melted, the water which it contains becomes explosive and usually suffices to break through the covering, constituting an eruption. When all the lava is erupted, and the reservoir is exhausted, it closes up for a time. If the heat continues to be generated, more lava is melted, and in due time another eruption occurs. The process may be repeated again. It may be repeated hundreds or thousands of times. The volcanic action may continue in the same place for hundreds of thousands, or even millions, of years, or it may repeat itself only a few times, or may even occur only once. Indeed, it may fail altogether to erupt to the surface, and in many cases does fail. In other words, it goes through the entire process of preparing for an eruption and does not consummate it.

This view enables us to explain the repetitive character of volcanic eruptions, which is, perhaps, their most striking and characteristic feature. It is in strong contrast with the view long held that the lava reservoirs are a part of the original constitution of the earth, and have lain in their present position through all the vast period of the earth's evolution, waiting for a convenient occasion to explode and pour forth their fiery contents. It regards the reservoirs as having no real existence as such, and as containing no liquid eruptible contents until some source of heat acts upon them and liquefies a portion of the strata, thus giving rise to the reservoir. When a sufficient quantity of the lava is melted to rupture its covering, the eruption follows. It continues until all the lava which exists for the time being in the reservoir is extravasated. And when all of its ammunition is expended, it must close its action until a fresh supply is provided.

By an increase of heat, we can readily understand the existence of the lava reservoirs in such anomalous positions near the surface of the earth. The horizon of melted lava, which has a temperature of about 1,000° or 1,200° C., if it depended wholly upon the secular cooling of the earth, would be more than thirty miles below the surface, or even forty miles below. We can not suppose that the cooling of the earth is so extremely unequal as to bring the isotherm of 1,000° C. at one place within two miles of the surface, and in another place, carry it thirty or forty miles below. It is equally difficult to imagine any subterranean disturbance or displacement which could mechanically thrust up near the surface a portion of the solid nucleus of the earth. Such a displacement is not warranted by the geological facts; for while volcanic eruptions occur frequently in localities where the strata are much displaced, they also occur where there has been no displacement of any moment since the Cambrian age.

A singular class of phenomena is found in the so-called mud volcanos which have always been a great puzzle, but which are easily explained by this cause. We find them in Central America and in Java, and the remarkable case of Bandai San, in Japan, is well remembered. These volcanos must have their origin at less depth than the lava eruptions. The temperature of erupted mud is not accurately known, but it can not be less than 400° or 500° F. The generation of heat half a mile below the surface would be a sufficient explanation of their origin and action.

Why should eruptions always emanate from shallow reservoirs and never from deeper ones? Or, according to the view here put forth, why are eruptive masses formed only at depths of two or three miles, and never at greater depths? I do not contend that no lava pools are formed at greater depths than three or four miles, but if they are formed, the lava is never erupted, and for the following reason. The pressure of the overlying rock at a depth of three miles is about 18,000 pounds to the square inch. At a depth of four miles it is about 25,000 pounds to the square inch. At such a pressure (25,000 pounds) it would be impossible for water vapor to lift its covering and force a way to the surface unless it had a temperature greatly exceeding 1,200° C. It would have to be heated to a considerably higher temperature to do it. But with increasing temperature the heat is conducted away more and more rapidly until the loss of heat is equal to the quantity generated, and thereafter there is no increase of temperature. The generation of radioactive heat is a slow process, and the only method of its escape is by conduction away from the radioactive source. The rate of heat generation is constant and independent of the temperature, but the rate of loss increases rapidly with the temperature. Ultimately, as the temperature rises, a point would be reached at which the loss of heat becomes equal to the gain.

If an eruption from a deep source, say five or six miles, were to occur, we should expect that the temperature of the lava would be very high—probably a white heat—and that its mass would be very great. Its consequences might be disastrous beyond all precedent.

That volcanism is caused by the generation of heat near the surface was a belief which I expressed over twenty years ago in a chapter of the work on Hawaiian volcanos. Long study of the volcanic problem, in which every other theory failed and went to pieces under criticism, and this alone not only survived but grew more probable and in accordance with the facts, led me to the hazardous step of venturing to express it. At that time, no cause could be cited for the increase of heat, and the proposition met with no response, and no doubt justly. Geologists continued to look for the explanation of volcanos in the gradually waning remnants of the earth's internal heat. Within the last five or six years, however, physical science has made discoveries of a wonderful nature, which open a new field, indeed, a new world, in our views of the constitution of matter, and may throw a flood of light on the very subject of our inquiry.

The subject of radioactivity is so new and so surprising that it has had time only to establish a very few of the fundamental principles which lie at the basis of it. But so hotly is the matter pursued by many of the ablest specialists that each year shows a large increase in our knowledge. As this is familiar to all physicists, I shall allude here briefly only to such as are essential to our discussion. We have to regret that some of the most fundamental questions concerning radioactivity are as yet unsolved, though we can not expect that a new and far-reaching science should in six years have accomplished all of its immense possibilities.

A good many efforts have been made, by the use of the extremely sensitive quadrant electrometer, to ascertain by measurement the quantity of radioactive substances in the accessible portions of the earth. By taking samples of earth from varying depths and testing them by the electrometer, widely variable quantitative results have been obtained, but in every instance the amount of radioactivity indicated much exceeds the amount required to compensate the loss of heat by the earth by conduction and radiation into space. For instance, Professors Elster and Geitel, of Berlin, who have made many discoveries and contributed many observations on radioactivity, placed 3,300 c.c. of garden soil within a closed vessel with an electroscope to determine the conductivity of the enclosed gas. Allowing it to stand for several days, the conductivity of the air became constant at three times the normal amount. This increase of conductivity, Professor Rutherford estimates, would be equivalent to that produced by the emanation from 7×10^{-10} grams of radium. If the density of the soil be taken as two, this corresponds to the emanation from 10^{-13} grams of radium per gram of clay. Now Professor Rutherford computes that the earth's loss of heat by conduction and radiation is equivalent to what would be supplied by 4.1×10^{-14} grams of radium per cubic centimeter of its mass. According, then, to the results obtained by Elster and Geitel, twice as much heat would be supplied by radioactivity as is lost by conduction and radiation into space.

This experiment with a small quantity of soil taken up in somebody's back yard will hardly be regarded as an accurate determination of such a quantity as the earth's supply of radioactive heat. But the question has been tested by many observers, whose results vary considerably, yet all are of the same order of magnitude. By sinking a pipe into the ground anywhere and sucking up a sample of the air from the soil, it is found to possess a much higher degree of radioactivity than the free air at the surface. It also has a marked degree of conductivity; and this conductivity falls to half of its initial value in a little less than four days, which is regarded as proving that it is due to radium emanation. The air of caves and cellars has been observed to have a marked degree of ionization, greatly exceeding the open atmosphere and the air in closed vessels. This is attributable only to the presence of radium emanation diffused from surrounding rocks or soils. Many common well-waters give satisfactory tests of the presence of radium emanation, which is soluble in water—more so than most gases.

The most pronounced occurrence of radium is in hot springs. Their waters always give evidence of its presence, and sometimes in quantities many times exceeding the air taken from the soil or cellars. Hon. R. J. Strutt, of Trinity College, has devoted much attention to the springs of Bath, and finds not only radium emanation in their waters, but actual radium in the deposits of the springs. The hot springs of Baden-Baden have been found to contain radium salts. M. Curie has tested a large number of the mineral springs of central and southern France and finds radium emanation in nearly all of them.

Mr. Boltwood, of New Haven, has devoted considerable attention to the study of radioactivity in mineral springs and finds that many of the waters of America contain radium emanation.

It does not appear that any extensive or systematic investigation of the emanations of active volcanos and volcanic gases has been hitherto made. The only one I can discover is the observation of Rausch von Trauenberg on the crater Vesuvius. The gases from that orifice produced marked ionization and a prompt discharge of the leaves of the electroscope. The subject, however, needs thorough investigation at many other volcanic vents.

The general result of the investigation, so far as it has gone, has been to make clear the fact that the amount of radioactivity in the earth much exceeds the amount which is necessary, so far as the heat generated by it is concerned, to compensate the loss of heat by conduction and radiation. In fact, it appears that the thermal condition at present is one of continual increase of internal temperature of a large portion of the earth, or is so in part; or else, is one of equilibrium between loss and gain. Undoubtedly the amount of radioaction varies somewhat widely in different portions of the earth's interior, in some portions permitting a loss of heat, in others permitting a gain. And when there is a gain, it may proceed in the portions near the surface so far as to liquefy the rocks, and thus furnish all the conditions necessary to volcanic eruptions.

One of the problems at present unsolved is whence comes this radioactive material, and what maintains its activity? For the most part, it gives us the characteristics of radium and in smaller degree those of thorium and uranium. The action of actinium has not yet been sufficiently pronounced to be recognized. Polonium is believed to be one of the transitional forms of radium. No other radioactive substances are yet known. The most important one thus far identified is radium. But the life and activity of radium is, from a geological standpoint, very brief. According to Professor Rutherford, and he is sustained by nearly all other physicists, radium is half consumed in a period of 1,300 years. In 13,000 years only the thousandth part of what now exists will be left, and in 26,000 years, only the millionth part will remain. Quite independently of geological reasons, the belief has been that radium is generated as the product of decay of some other element, and that the amount of it in nature is sensibly constant. It is generated as rapidly as it decays. The parent element from which it may be derived is not yet decided, but there are some who suspect it to be uranium, which has immensely long life. It requires nearly 120,000,000 years to be half consumed by its own decay.

But we are not interested in pursuing and trying to test these unsolved problems. It is enough for us that radioaction exists in sufficient quantity and intensity to furnish heat enough to meet the wants of the vulcanologist.

Let us now look for a moment at the presumable details of the process. At a depth of two or three miles in the earth let us assume that radium is in process of being generated. It starts at once upon that process of transformation of which one stage is the production of the so-called emanation, which is a gas of very high density and great penetrating power and diffusibility. We know that the upper strata and soils everywhere contain it, and no reason appears why the same should not be the case with the rock beneath. Wherever the emanation penetrates, the break-up of its particles generates heat and the temperature rises in proportion to the amount of emanation which undergoes transformation in a given time, and falls in proportion to the rate at which it is conducted away. So long as the gain of heat exceeds the loss, so long will the temperature rise until it becomes sufficient to melt the rocks.

All volcanic lavas contain water and those whose reservoirs are near the surface contain a large amount of it. Those which have a deeper origin contain a smaller amount of it. The deeper lavas are hotter and are erupted with less violence and in greater mass than the shallow ones, and the reason is obvious.

AN ECLIPSE EXPEDITION TO SPAIN

By Dr. S. A. Mitchell
Columbia University

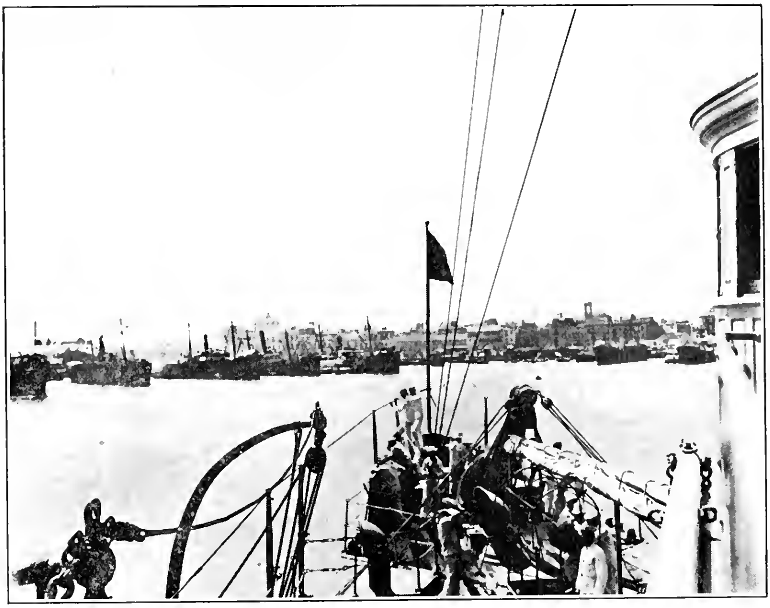
If we could sum up the total duration in minutes and seconds of recent eclipses, we should be astounded that astronomers from such phenomena have discovered so very much. Since the spectrograph and the photographic plate were first used together at an eclipse, the sun has been covered up by the moon somewhat less than twenty minutes of time, yet, in these few moments, a great wealth of information has been gained from the eclipsed spectrum. Each eclipse settles some problems, and teaches us how to attack others, and astronomers are most enthusiastic at such a time, trying new instruments and improved methods of research. More interest was shown in the 1905 eclipse than ever before, one reason for this being that the moon's shadow path fell upon a readily accessible part of the globe, and the eclipse occurred at a time of the year (August 30) when most college men were having their summer vacation. At the last eclipse, in 1901, American astronomers had to travel as far away from home as possible, in that a trip half way round the world was taken; and when one considers the number of instruments, and the great amount of freight that the modern astronomer has to carry with him, the task is no small one.

At the eclipse of last year the moon's shadow touched the earth's surface at sunrise in Manitoba, and after crossing through Canada at cannon-ball speed, it left Labrador about 8 A.M. on its trip across the Atlantic. Shortly after noon the shadow cut into Spain, then on through the Mediterranean, northern Africa, Egypt, and left the earth's surface at sunset on the coast of the Indian Ocean.

Spain was chosen by the majority of astronomers, both because the duration of totality was longer, and because the weather conditions promised better; and here in a path one hundred and twenty miles in width running diagonally across the peninsula, hundreds of astronomers, American and European, were gathered.

The party sent out by the United States government was under the general direction of Rear-Admiral Colby M. Chester, U.S.N., superintendent of the Naval Observatory. Three men-of-war were furnished by the Navy Department for the purposes of the expedition, the U. S. S. *Minneapolis*, U. S. S. *Dixie* and U. S. S. *Cæsar,* the first named being the flagship of the squadron.

The three vessels left separately from the United States about the end of June, and met in Gibraltar about the middle of July. 'Gib' is one of the most interesting places in the world, especially when entering on a naval vessel. It was a glorious sight, as we steamed in at dawn, to behold the wonderful rock, and sheltered at its base the Mediterranean squadron of the British navy, consisting of eight battleships and eight first-class cruisers, under the greatest of English admirals, Lord Charles Beresford. The morning of our arrival was spent in firing and acknowledging thunderous salutes, and in making official calls. To properly carry out these acts of courtesy between the American and British nations, it was necessary to fire no less than one hundred and fifty-two rounds of ammunition. On the morning of our second day in Gibraltar, the British squadron sailed, and it gave us an



U. S. S. MINNEAPOLIS, ENTERING VALENCIA HARBOR.

idea of the quality of the greatest navy in the world to see the splendid, seamanlike manner in which the big ships got under way, and without confusion, and in splendid order one by one depart from the crowded harbor.

Gibraltar covers only about two square miles, so it did not take much time for us to take in all the sights of the streets with their motley population of English, Spanish and Moors, and to visit the places of historical interest. The 'Key of the Mediterranean' stretches almost exactly from north to south with a length of three miles and a breadth of little more than half a mile. The north and east sides of the 'rock' are almost vertical, while to the south and west it descends in step-like terraces, and thus it is only a small portion of the area of two square miles that is habitable. From the foot of Mt. Rockgun

(1,356 feet) the land stretches northward towards Spain in a low-lying flat isthmus not more than half a mile in width. The central portion of this, a third of a mile in width, is kept as a neutral zone between the Spanish and British possessions, and is lined with sentry boxes on either side. The fortifications of the side towards Spain consist mainly in galleries hollowed out in the face of Rockgun during the four years' siege ending in 1783. Signal Station (1,295 feet) and Highest Point (1,396 feet) are surmounted with great guns which defend the twelve miles of strait that flow between Europa point and Africa.

Entering the blue waters of the Mediterranean, the *Minneapolis* steamed along the coast of Spain for about four hundred miles and

ECLIPSE PARTY AT DAROCA.

anchored in the harbor of Valencia, the first American man-of-war to visit a Spanish port since the late unpleasantness.

At Valencia, the home of the 'Cid,' the annual fair was in progress, and the chief attraction was the bull fight. During the eight days of the fair, five *Corridas de toros* were held. Six bulls were killed at each of four of these fights, and in the other, 'extra-special' fight, eight bulls were slaughtered. Those of us who went to the first of these disgusting spectacles saw six bulls and nineteen horses butchered, and it is hardly necessary to remark that we did not go a second time.

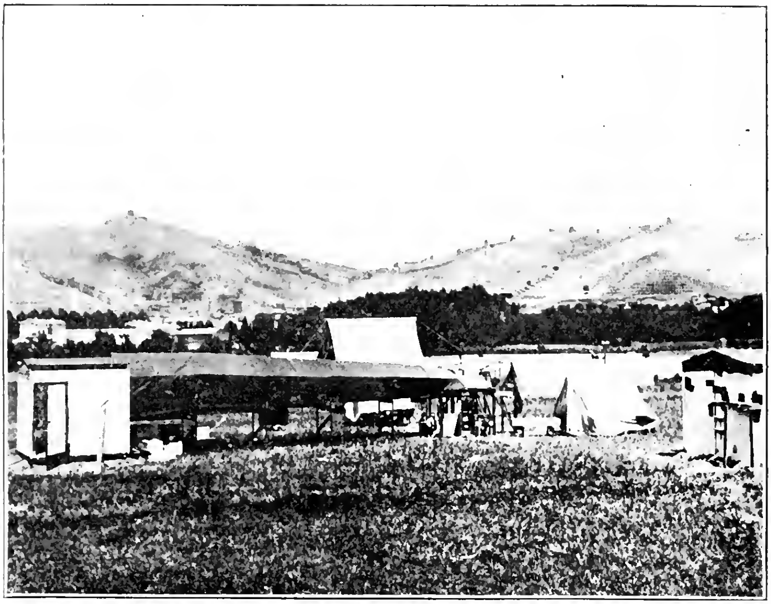
The bull ring is of the shape that the name signifies, the one in Valencia being the largest in Spain, capable of holding 17,000 people. The fight is opened by a procession into the ring of those taking part.

At the head of the procession walk the *Espadas,* then come the *Banderilleros,* the mounted *Picadores* and the attendants (*Chulos*) on foot with a team of gaily bedecked mules used in dragging off the dead bulls and horses. The fight can be described as follows:

It is one of three acts. In the first act the *picadores* receive the charge of the bull, which they try to withstand by prodding him with their pikes. In nearly every case horse and rider are overthrown by the bull, and the horse terribly gored. The bull's attention is attracted as quickly as possible by the waving of cloaks in the hands of attendants, and he is enticed to leave the prostrate man and horse. This performance is repeated several times until the bull becomes a little wearied. The second act now begins, and in this a *banderillero* on foot will meet the bull in full charge, stick into his neck on either side two barbed darts about thirty inches long covered with colored paper, and step nimbly aside to escape the enraged animal. Usually eight of these darts are used. In the third and last act, the *espada* teases the bull with his red cloth and manœuvers to get the weakened bull in a favorable position to give the death stroke by thrusting his sword through the neck and into the bull's heart. Great is the applause when the bull falls dead from a single stroke. The dead bull and horses are dragged out by the mule team, the ring is sanded to cover up all traces of blood, a new bull is let in and the fight goes on as before. (A bull fight is quite expensive. Each bull costs about $250, and horses, though poor, cost something. The animals killed in the ordinary *corrida* are worth at least $2,000.)

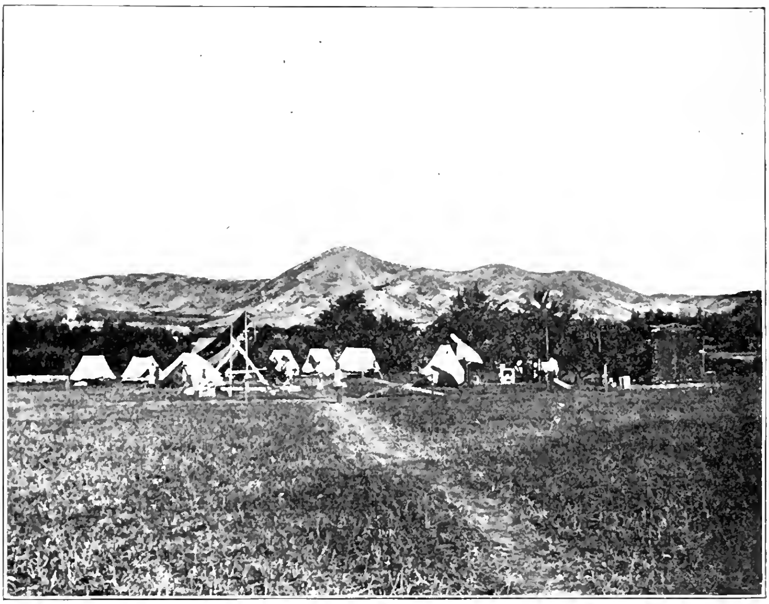
It had been decided to divide the Naval Observatory expedition into three, sending two parties to Spain and one to Africa. The U. S. S. *Dixie* took the African party to Tunis, and the astronomers Jewell, Gilbert and Dinwiddie located themselves at Guelma near the central line of the shadow cast by the moon. In Spain there were two parties, one located at the edge of the path of totality at Poerto Coeli, and the other near the central line at Daroca. At the former place were Lieutenant Commander Hayden, Professor Littell, Mr. Peters and Mr. Hill from the Naval Observatory, and Mr. Anderson from the Johns Hopkins University; at the latter place were stationed Professor Eichelberger and Mr. Yowell of the U. S. Naval Observatory, Professor Bigelow of the U. S. Weather Bureau, Mr. Hoxton of the Johns Hopkins University, and the writer.

Daroca is in the heart of old Spain, about forty miles from Saragosso, and as a railroad has been there only four years it is a *terra incognita* for modern tourists—for which we were duly thankful. Our six weeks' stay there was a happy commingling of hard work—and there was plenty of work to do—with pleasant experiences in getting acquainted with Spanish life and people. The site for the town is indeed a peculiar one, in a valley so surrounded by hills that each



ECLIPSE CAMP DAROCA, LOOKING NORTH.

heavy rain storm used to flood the city till, about 1600, a tunnel was constructed through one of the hills to carry away the waters. The tops of these hills are crowned with walls and forts, most of them constructed by the Moors a thousand years ago, some of them by the



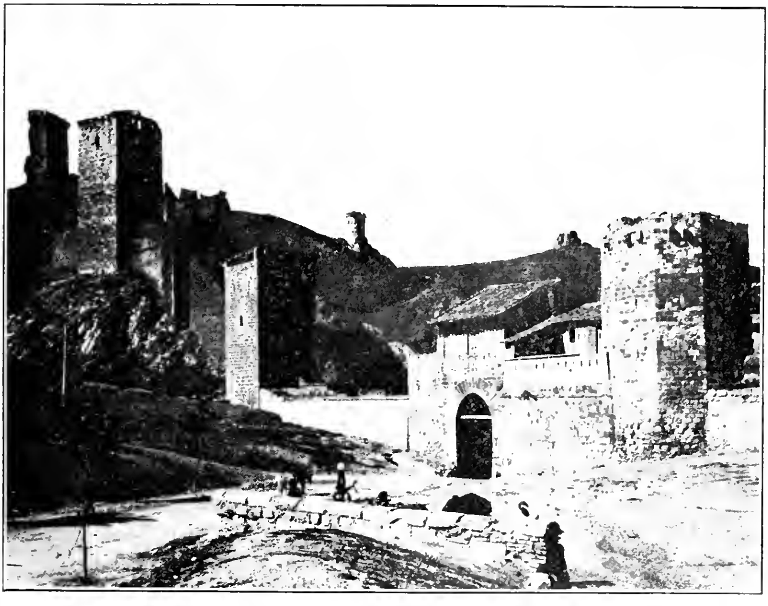
ECLIPSE CAMP DAROCA, LOOKING EAST.

Catholic Spanish since that time. There is one tower of special interest, and still in good state of preservation, which is said to have been built by the Romans before Saguntum was founded, and it is, therefore, more than two thousand years old. (The railroad from Valencia passes through Saguntum where Hannibal and the Romans had their memorable fight in B.C. 238.)

The Spaniards received us with open arms and did everything in their power to assist in our work and to make our stay in their midst as pleasant as possible. As no one in the place could speak English, it was necessary to make ourselves understood in their language. They did not laugh at our mistakes in grammar or pronunciation, as we might have done in their places, but were always and at all times the souls of politeness and courtesy.

To help in the erection of the observatory, six sailors were sent in from the *Minneapolis,* and all hands, astronomers and sailors, worked each day from early morning till late at night, building piers, erecting telescopes with houses to shelter them, mounting spectroscopes, and fixing up a meteorological observatory. After the carpenters and machinists had finished their work of construction, it was necessary for the scientists to focus and adjust, to see that everything was in good working order, and to make trial photographs. A few days before the eclipse the party increased in size to thirty-five, officers and sailors having come up from the ship for the purpose of assisting in the observations. Frequent drills were held in order to familiarize each one with his part and thus to be sure that everything would go right and that no precious seconds would be wasted at the time of the eclipse.

There are certain things about the sun of which we still know very little: for instance, our information of the corona does not go very far. This wonderful halo, without doubt the most beautiful of all natural phenomena, can be seen only when the sun's light is totally eclipsed. As long as there is a slight trace of the sun's disc to be seen, its light is so overpowering that the corona is obliterated; but the instant the moon completely covers it up, there flashes out instantaneously the gorgeous crown of light to view which is well worth traveling thousands of miles. At this eclipse the corona lasted for three minutes and forty-five seconds, and almost with the first reappearance of the sun it was gone. Although this crown must be at all times around the sun, astronomers have not yet become expert enough to make it visible without an eclipse. The shape of the corona, too, is peculiar in that it is in some manner connected with the number of spots on the sun. When there are very few spots, the corona is winged out on either side along the sun's equator, while in the years that the spots are many, the streamers run out at all angles and the corona is more or less square in shape. We have known for more than fifty years that there is some close bond between the number of spots and the amount of magnetism in the earth. This terrestrial magnetism is evidenced through changes in the compass needle, in frequent magnetic 'storms,' and in the beautiful northern lights. The sun spots are thus the seat of some great solar activity of whose exact nature we are at present not sure. Moreover, the sun is not sending to the earth a constant amount of heat. Very recent observations in Washington show that these solar fluctuations are followed very closely by variations in temperatures all over the earth. Whether these newly discovered variations in the sun's heat are connected with the spots on the sun, or not, it is too early to say, but it may not be outside the bounds of possibility to be able in the future to forecast the great variations in our earthly temperatures from observations on the sun. We realize, then, the importance of



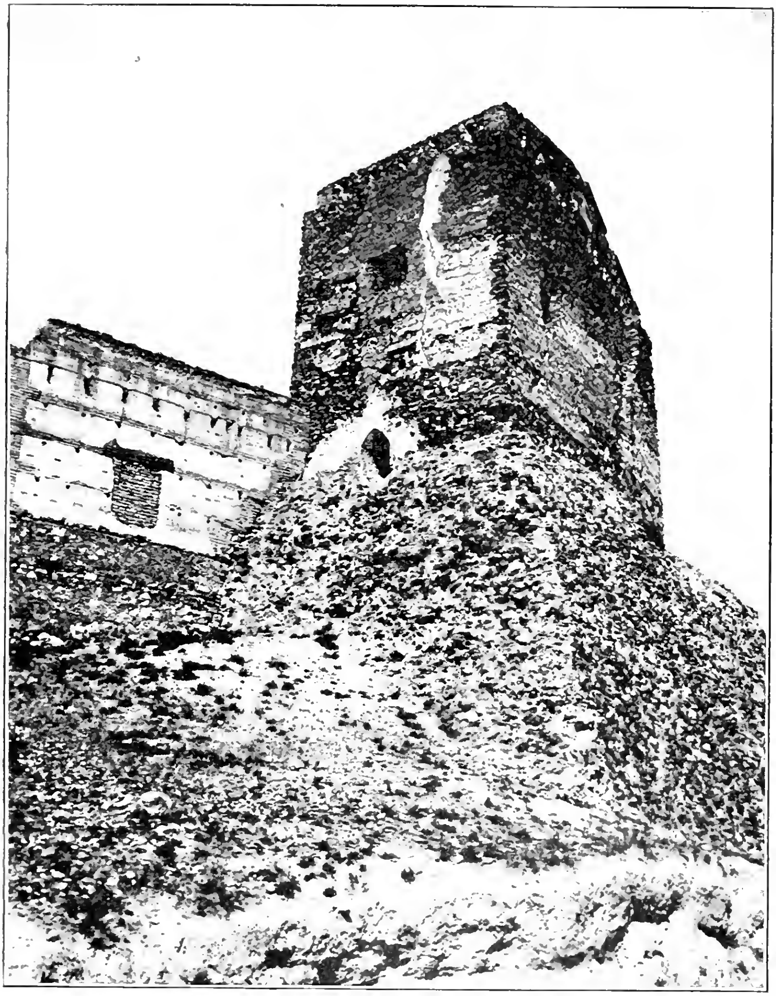
North Gate, Daroca.

these observations on the sun, and it is for the solution of problems such as these that eclipse expeditions are sent out.

To investigate the corona, photographs are taken of all sizes. The diameter of the sun on the photograph depends on the length of the camera, the greater the focus the larger the sun. At Daroca the largest camera used was forty feet in length, which gave an image of the sun four inches in diameter. In photographing, the lens can be mounted pointing directly at the sky, or else the whole instrument can be placed horizontally and light be reflected into it by means of a mirror. We adopted the latter way as being the easier.

The location of the eclipse camp was half a mile south of the town, in the midst of a beautiful, fertile valley. From there, while we worked, we could catch glimpses of scenery typical of Spain. The first feature to attract your attention is the extremely barren aspect of the country, which is in sharp contrast with the garden-like appearance of England. The hills of Spain were in early times densely wooded, but now are almost entirely devoid of trees and look from a distance as if there were not a particle of vegetation on them. Moreover, the rainfall is so slight that agricultural pursuits must rely upon irrigation for their carrying on, and thus it is only the valleys that are green and cultivated. In such a valley along the shores of the little river was our eclipse camp located. The greenest field was decided upon as the site of the observatory, and upon application to its owner for permission we found that he was quite satisfied to allow his plot of ground to be used, but thought some compensation should be made for the valuable crop of grass that might possibly be raised during the summer. On receipt of one hundred pesetas, he forthwith proceeded to take a fatherly interest in all of our doings, and explained scientific matters to every one as if he had been chief of the expedition. His field became the center of interest in the community, and people came from all sides to look upon the strange doings. As a prominent trait in the Spanish make-up is a great and overpowering curiosity, we had plenty of onlookers; and when the mayor and a few of the most prominent citizens were invited to look at the moon through our five-inch telescope, we were rather surprised—to put it mildly—to find over one hundred people turn up, when only a half score had been invited. Their curiosity took the form only of making each and every one in the town intensely interested in what was going on, and to show that interest they turned out in force each afternoon to see how matters were progressing. It might be asked, what was their attitude towards these Americans who had so lately beaten them in their small war. Before the expeditions reached Spain, it was feared that perhaps there might be some friction on that account, but these fears were not realized. As a matter of fact, the only person we met who seemed to have any feeling in the matter was a former soldier in the Spanish army. He had seen service in the Philippines, had been captured and thrust into prison by the Filipinos, had been rescued by the Americans, and as a result he had only the kindest of feelings towards everything belonging to the United States. As for the rest of the people, they seemed to have forgotten all about it, or else they did not know there had been a war, for it must not be forgotten that only about one quarter of the people in Spain can read and write.

Besides getting photographs of the corona of different sizes, the astronomers at Daroca were using the most powerful spectroscopes ever employed at an eclipse, for the purpose of investigating the nature of the light of the sun and its surrounding region. There are two ways of producing a spectrum. The best known method is by means



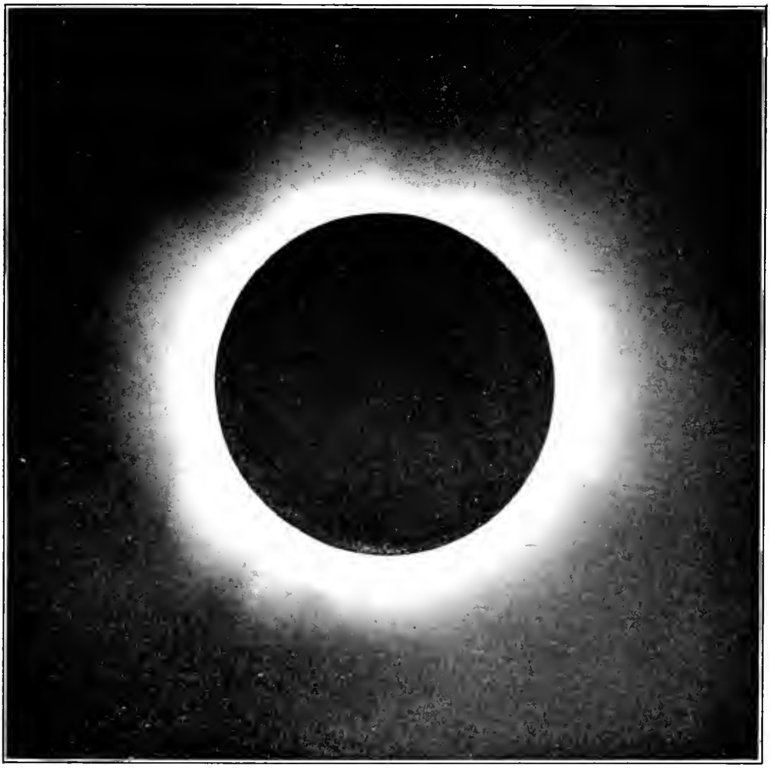
MORE THAN TWO THOUSAND YEARS OLD.

of a triangular prism of glass which breaks up the white light of the sun into its component colors of red, orange, yellow, green, blue, indigo and violet. The other and better way is by the use of a grating. Such an instrument is made by ruling on the surface of a plane or concave mirror many thousand fine lines separated by equidistant intervals. The writer had mounted for his use at the eclipse five spectroscopes, two being prisms, the others gratings. By means of these a great variety of problems were attacked, such as the constitution of the atmosphere immediately surrounding the sun and the heights in miles to which the different gases extend above the sun's surface, the nature of the gases that go to make up the beautiful corona, the amount of heat and energy of the corona, etc.

After this my third total eclipse, I can confidently say that observations at such a time consist of much hard work and many nerve-racking experiences. One is never on hand sufficiently long beforehand to take things quietly and easily, you must work under conditions you are totally unused to, and over your head hangs the knowledge that everything must be completed by a certain day and a certain hour, for the eclipse can not be postponed, and there is no second trial in case of failure. In addition to working hard all day as carpenter and instrument maker, the astronomer must stay up half the night adjusting his instruments on stars, so that during the last few days before the eclipse very few hours of sleep each night are obtained. However, in spite of the many difficulties that were continually cropping up, the mounting and adjusting the instruments were practically completed by August 25, when our observing party was swelled in numbers by the officers and men from the *Minneapolis*. From then till eclipse day the time was spent in putting the finishing touches on the work of adjustment, and in having frequent drills in order to insure that everything would go without a hitch.

Eclipse was to occur shortly after noon on August 30, and for many days beforehand we had been carefully scrutinizing the weather in order to see what conditions we might possibly have to expect. As a rule the sky was clear at eclipse time. It would have been dreadfully disappointing to have had a cloudy day, or even to have a stray cloud cover the sun during the important few minutes of the total eclipse. Such a thing happened at the last eclipse in 1901 after traveling half way round the world. Where some of the observers were, the sky was so overcast that it was impossible even to see where the sun was. At the 1905 eclipse darkness lasted for the space of three minutes and forty-five seconds, and it was only during these few minutes, after weeks and months of preparation, that the real work was to be done. August 29 had been cloudy all day so that on eclipse day we had to go to camp early to test our final adjustments, go through drills once more and to be sure that all the apparatus worked smoothly. The skies were clear and our hopes for success were high. Outside the roped-off enclosure, the whole town of Daroca was assembled, for it was naturally thought that nowhere could the eclipse be seen so well as where the astronomers were located.

At 11.52 A.M. a little shadow was seen on the western limb of the sun, and the eclipse had begun. The skies were clear with the exception of a cloud here and there, and our most ardent wish was that the clouds would leave the sun clear for the next couple of hours. For the first hour that the moon was creeping over the sun there was nothing of very great moment to notice, but for the next twenty minutes till 1.12, when the sun was blotted out, we were each of us filled with expectancy, for matters began to take on a weird and unnatural appearance. The little blotches of light under the trees, instead of being the familiar circles, were little crescents, exact counterparts of the sun itself. The darkness began to make itself really felt, and without looking at the sun one would know that something out of the ordinary was happening, for the gloom did not in the slightest degree resemble that of sunset. A hush fell upon the crowd of assembled and talkative Spaniards when, ten minutes before totality, a big cloud drifted over the sun. Would this cloud move away? Or were we going to be disappointed? It hung there for a space of time that seemed to be an age, while in reality it was only five minutes. It was a big scare, but when



CORONA, August 30, 1905. 83 seconds Exposure. Photographed with a 40 ft. camera by W. W. Dinwiddie.

that passed, with a shout from us all, there wasn't another cloud anywhere to bother us. Fifteen seconds before the calculated time, with the last disappearing ray of sunlight, the corona broke forth into view. What a magnificent sight it is shining out with its pale, pearly light for a couple of diameters round the edge of the sun, with its streamers and brushes of delicate light! True to prediction, the corona was almost square in shape, and was not at all alike in appearance to the other coronas the writer had seen in 1900, and 1901, with their long fish-tail extensions along the sun's equator and short-curved steamers near the sun's poles. In the upper left-hand quadrant huge red flames sixty thousand miles high could be seen with the naked eye, which with a closer view with the telescope resolved themselves into a forest-like structure. These we know are great jets of burning hydrogen gas. Close to the sun the corona was very bright, in fact so bright that the eye was not readily able to take in all the details of the faint streamers. As a pictorial effect without the long equatorial extensions, this corona was much inferior to the two last ones seen. Still it was a magnificent sight, and we were more than thankful for having clear skies to make our observations.

When totality first started we were each and all of us much too busy to take much notice of our immediate surroundings or even the corona itself. We could not help becoming aware that our Spanish onlookers outside the ropes were appreciating the show in the skies provided for them without expense. From the noise made each one seemed to be telling his neighbor at the top of his voice just how it happened and what there was worth seeing, and this in spite of the fact that the mayor of Daroca had generously provided half a dozen members of the civil guard to preserve order and keep quiet. For the first half minute the din was so great that it was impossible to hear the seconds counted, or to know exactly when to begin and end the exposures of the photographs, for at present-day eclipses all important observations are made by photography. The impressions received by the eye are so fleeting, coming to the observer when he is not in his usual calm, calculating mood, but aroused by excitement and novelty, so that it would be no wonder if in the past mistakes have been made in interpreting the celestial phenomenon. At present-day eclipses, with the aid of the photographic plate, the astronomer devotes his attention to getting a good series of photographs, and after the few minutes of the eclipse are over the plates can be developed and permanent records obtained which can be studied at leisure through weeks, months and perhaps years. When the Spaniards had quieted down, after their first outburst, all that was heard in the eclipse camp was the steady count of the observer calling out the seconds as they passed, the quiet words of the observers giving commands to their assistants and the click, click of the apparatus as exposures were made and plate holders moved. Everything passed off without a hitch, and with the first reappearance of the sun our work was over and we could take a long breath.

We had been favored with clear skies, how many others were equally fortunate? It did not take us long to find out, for the Spanish government had installed right in our camp a telegraph office, and for fifteen days no less than three operators were at our service to send and receive our messages; and for this not a single cent of money was asked or expected. It was found that fifty miles to the west of us, at Alhama, where were the observers from the Lick Observatory under Professor Campbell, there were thin clouds, while one hundred miles to the east along the Mediterranean coast the Englishmen were even more unfortunate in having the clouds denser. In the northeastern part of Spain at Burgos more astronomers were located than at any one place, and here too was King Alfonso of Spain. Five minutes before totality it was pouring rain there, but as if by a miracle a little blue patch of sky appeared, and the eclipse was seen under perfect conditions. The weather along the eclipse track was: in Labrador, cloudy, no observations made; in Spain, cloudy and clear; in the islands of the Mediterranean, cloudy; on the coast of Africa, slightly cloudy; but further inland and along the rest of the eclipse track the skies were perfect. All three parties of the Naval Observatory were fortunate in having their work unhindered by a single cloud.

My own work was entirely spectroscopic. The photographic plates were developed within the walls of the college of Daroca, and in the long hours necessary for this work I was greatly encouraged and assisted by my good friend the rector of the college, Padre Felix Alvirez. Daily intercourse with this reverend father endeared him to me very much, and Srs. Lorente, Soria and Padre Felix made my stay in Daroca one of the most interesting spots of my whole life by the kindness with which they bore my imperfect Spanish, by the interesting bits of history they told of Daroca and by the deep insight each gave of the courtesy of a Spanish gentleman's heart.

The developed plates show that a great amount of detail had been caught, on one plate there being no less than twenty-five hundred lines all in good focus. A careful and accurate measurement made of the position of these lines of the spectrum will give much of scientific interest about the constitution of the sun's atmosphere.

As a result of the observations of this latest eclipse much valuable information will undoubtedly be gained about the sun and its immediate surroundings. These discoveries, however, will all be in minor details, and it is hardly probable there will be any wonderful or startling revelations made.

It is a long time till the next eclipse to be generally observed in 1912, and astronomers will have plenty of time to fully investigate their photographs of this past summer.

The instruments that took weeks to mount and adjust were easily pulled apart and packed, and in a few days after the eclipse everything was in readiness to be transshipped home.

The writer left Spain with many regrets, and with many happy recollections of a pleasant and profitable time spent among the courtly Spaniards.

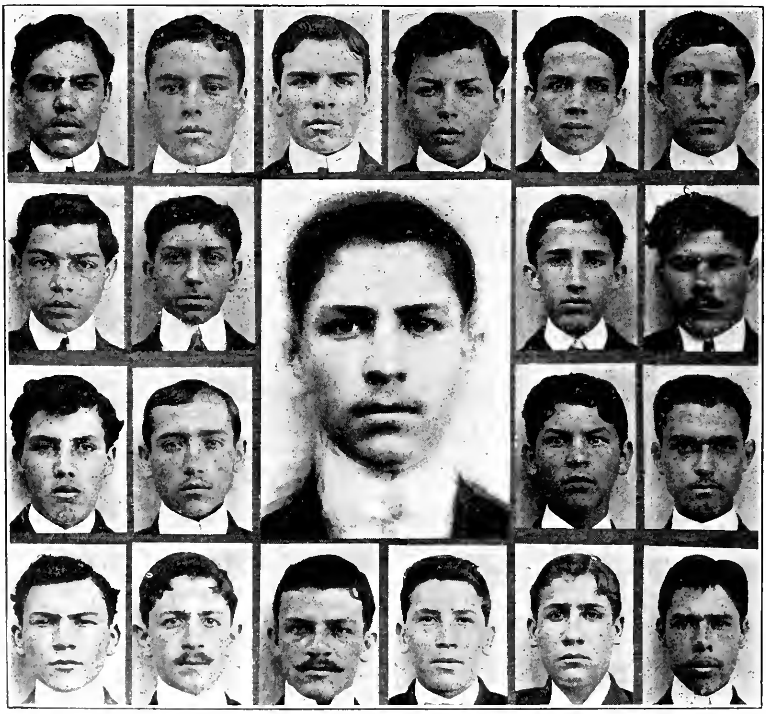
SHORTER ARTICLES

THE SPANISH AMERICAN TYPE

THE twenty portraits reproduced here are those of Central American students taken in a haphazard way in a Costa Rican government college. The composite photograph expresses well enough the features common to most of them: the large, dark, dreamy eyes and the relief of both mouth and chin. It may be considered as a good illustration of the Spanish American type. Mexico receives an increasing American element; Brazil and Chile are somewhat Germanized; Argentine is flooded with Italians; in Central America, the race, the habits and the language are still comparatively free from foreign admixture.

By foreign I mean exotic. A stream of Indian indigenous blood flows in the veins of a large number of Central Americans. It reveals itself here and there on some of the faces which surround our central picture.

Aside from that occasional modification the Spanish American is not unlike his Spanish cousin. His features are those of the Mediterranean race. His skull is dolichocephalic. His body is slender. The stature is variable although generally inferior to that of the Baltic race. The circumstances



COMPOSITE PHOTOGRAPH GIVING THE TYPE OF THE SPANISH AMERICAN STUDENT.

which determined the migration from Spain were not such as to induce a physical divergence between the two branches. In other words, those who departed did not differ in bodily appearance from those who remained.

They differed greatly in mental propensities. When, under the reign of Charles I., marvelous stories concerning the strange and beautiful lands discovered by Columbus, Cortez and Pizarro were circulated in Spain, excitement prevailed all over the peninsula. The practical, matter-of-fact people smiled with incredulity, but the imaginative, the chivalrous, the restless, sold all and sailed. Here is the main fact which is to borne in mind when the present nature and tendencies of the Spanish Americans are considered. Restless, alas! they are and somewhat restless they may remain, yet they are neither dull nor obstinate; they see their worst defect as clearly as others see it and try to overcome it. If strifes are still frequent among them, on the other hand, the first international treaty of permanent arbitration was the work of two Spanish American countries, and that treaty was by far more comprehensive, and thereby more efficient, than any of the similar treaties recently made in the northern hemisphere.

Restless and not practical, but also warm hearted, impulsive and generous, in olden times, many Spanish noblemen sailed because they felt sure to find in the American Eldorado the fountain which confers perpetual youth on all who bathe in it. They went through many vicissitudes, became old and died far away from the land of their fathers without having realized their dream, but it seems to-day as if some of the marvelous waters were present in all the rivers which run down from the Andes, for the defects of the Spanish American, as well as his qualities, are but those of youth.

GUSTAVE MICHAUD.

THE PROGRESS OF SCIENCE.

THE EARTHQUAKE ON THE CALIFORNIA COAST

It is too late to describe here the appalling disaster that has overtaken San Francisco and the neighboring regions and too soon to attempt to present a scientific survey of the causes leading to the catastrophe and the precautions that should be taken to avoid its recurrence. We can but add one more expression of the universal sympathy and a further appreciation of the undaunted courage which leads men to assert their supremacy even in the face of the most terrible exhibition of the powers of nature.

The progress of science and the conditions of modern civilization have been the chief causes of the calamity; yet we may confidently look to the same factors to prevent its recurrence. Earthquakes occur daily, and a shock such as that of April 18 would have done but small damage to a farming community. The trouble was due, on the one hand, to large piles of masonry or flimsy brickwork unsuited to resist vibrations, and, on the other, to the conflagation. The live electric wires, the methods of heating, lighting and applying power, the dependence of a modern city on its fire department and a supply of water through mains, not only explain the San Francisco fire, but made it almost inevitable. On the other hand, the steel frames and concrete reenforced with steel wires, proved themselves, as had been foreseen, well fitted to resist destruction. The only trouble was the shaking off of the stones and bricks and the inflammable contents. If it were not for the esthetic effects, such buildings might be covered with metal sheathing and be made fire-proof within as well as without. They would then be earthquake-proof—at least for such shocks as are known to have occurred—and would be as effective as open spaces in stopping the spread of a conflagation. San Francisco will take all needful precautions. Whether cities less likely to suffer should do so is more doubtful. The effects of an earthquake in New York City would be appalling. The people would rush into the streets, too narrow to hold them, while the stones would be shaken down on their heads, the conditions being similar to those of a vast theater fire. But more lives are needlessly sacrificed in New York City each month than have been lost in the California disaster, and more money is wasted each year than is needed to rebuild San Francisco.

The causes of earthquakes are somewhat obscure and are doubtless of different kinds. They are part of the vast terrestrial phenomena which have lifted the continents and the mountain ranges. The main stresses may be due to contraction of the crust of the earth or to changes in its shape, while the proximate causes are the local geological formations. The conditions at San Francisco are fairly well understood. There is a fault in the peninsula along the Portolá Valley, where for about forty miles the rocks on one side have at some time sunk two thousand feet. At the time of the recent earthquake, the land on the west side of the fault was forced northward from three to six feet, and the violent dislocation accounts for the shock. Mr. G. K. Gilbert has been instructed by the U. S. Geological Survey to make a thorough study of the causes, and we may be able to print a special article on the subject in due time. In the meanwhile there is given above an article by Professor Turner on our present knowledge of earthquakes. There is also printed in this number of the MONTHLY a paper by Major Dutton suggesting a hypothesis to account for the allied phenomenon of volcanoes. Those of our readers who wish to inform themselves on the nature of earthquakes and the methods of recording and studying them should read the book on the subject by Major Dutton, recently published in the 'Science Series' by the Putnams.

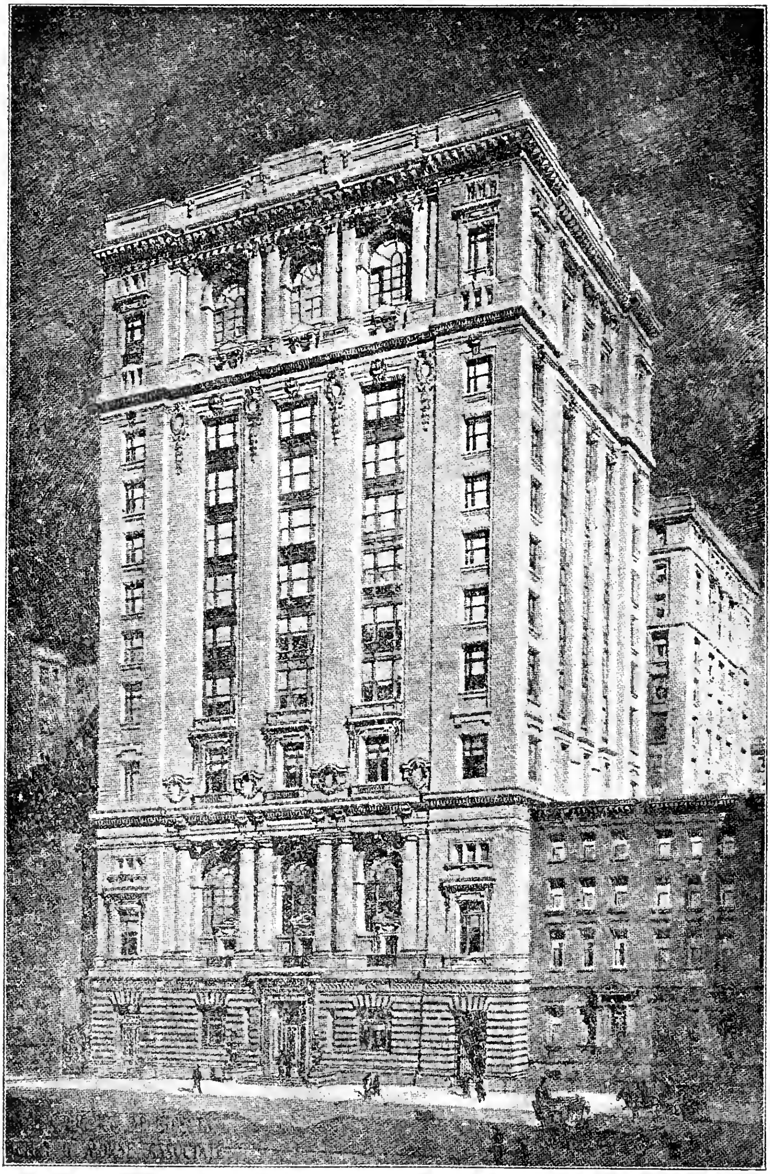
THE ENGINEERING BUILDING OF NEW YORK CITY

THE corner stone of the United Engineering Building in New York City, already more than half completed, was laid on May 8 by Mr. Andrew Carnegie, to whose munificence the building is due. It will be remembered that, in view of Mr. Carnegie's gift of one and one half million dollars, the United Engineering Society was incorporated on May 11, 1904, under the legislature of the state of New York for "the advancement of the engineering arts and sciences in all their branches, and to maintain a free public engineering library." The 'Founder Societies' represented in the corporation are the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Mechanical Engineers. The building of the United Society will provide permanent headquarters for these three national engineering societies and for the Engineer's Club, and also places of meeting and office room for such other engineering and scientific societies as may from time to time be admitted as 'associates.' Power to administer the trust is invested in a board of trustees of nine members, consisting of three representatives elected by each of the Founder Societies. The expense of maintenance must be shared by the three societies participating in the foundation, in accordance with regulations imposed by the United Society. The following are the charter members of the corporation: Charles F. Scott, Bion J. Arnold and S. S. Wheeler, of the American Institute of Electrical Engineers; C. W. Hunt, F. R. Hutton and James M. Dodge, of the American Society of Mechanical Engineers; A. R. Ledoux, Charles Kirchoff and Theodore Dwight, of the American Institute of Mining Engineers.

The building of the new society is in process of erection on the north side of thirty-ninth street, between Fifth and Sixth Avenues, the site covering five city lots with a total front of 125 feet and a depth of 100 feet. The new building utilizes only 115 feet of the front and as it controls the other side, space is left on all sides of the granite pile of thirteen stories, which thus presents an imposing monumental appearance. The plans are entrusted to Messrs. Hall and Rogers, and Henry G. Morse, associate architects, for the three engineering societies and Messrs. Whitfield and King for the Engineering Club. The building, as shown in the illustration, is a notably worthy product of the modern science and art of building construction that may well serve to typify the purposes for which it was conceived.

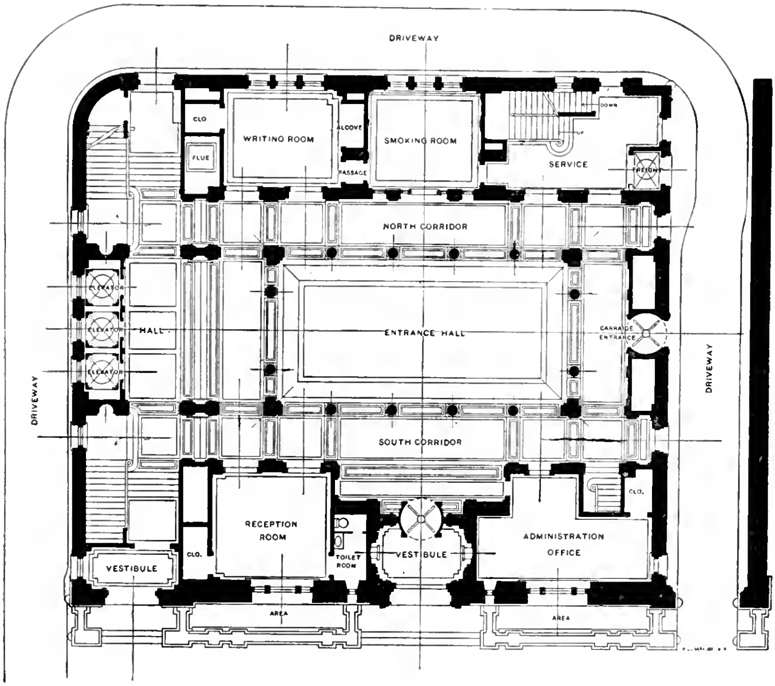
Primarily it must serve the convenience of the individual societies which enter it as founders. To this end a floor provides adequate rooms for each of the societies, as shown in the case of the electrical engineers in the accompanying plan. In addition meeting rooms and auditoriums are to be furnished for the regular and special meetings of the societies and for scientific lectures and demonstrations. Other assembly rooms have been specially adapted to suit the various uses for which they may be required.

There is one large auditorium with accommodations for 1,000 persons, on the first floor above the street. The foyer and corridors afford ample space for withdrawal from the assembly hall,

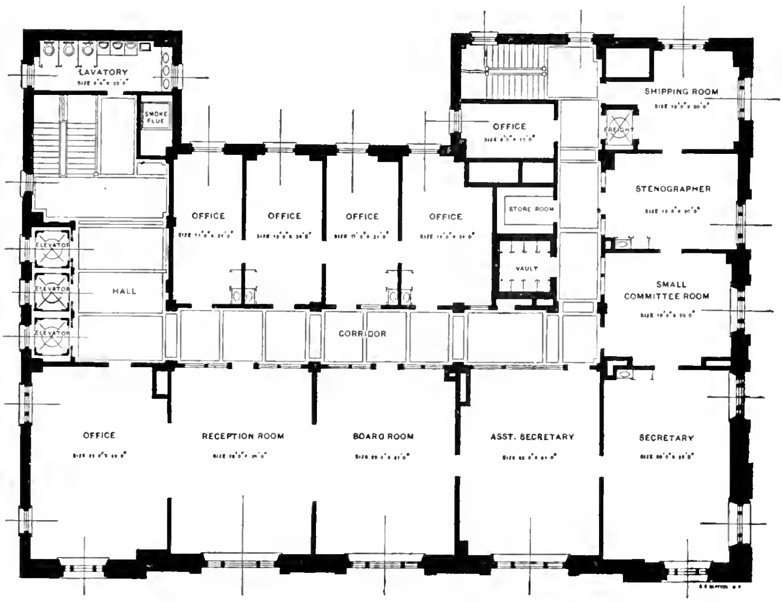


THE ENGINEERING BUILDING.

which offers means of exit at all four corners. The seats are arranged on a grade conforming to the modern practise in theaters. On the floor above are two assembly rooms with a seating capacity of 450 and 300 persons, respectively, which may be used, as preferred, independently or together. Smaller assembly, conversation and service rooms adjoin. On the floor above are lecture rooms for smaller meetings or for the sectional meetings of large organizations. These will be supplied with electric current, with compressed



ENTRANCE FLOOR OF ENGINEERING BUILDING.



TENTH FLOOR, OCCUPIED BY THE ELECTRICAL ENGINEERS.

air and also gas and water, and all meeting-rooms will be fitted for the use of the projection lantern.

Commodious provision is made for the libraries of the various societies on the two upper floors. The entire top floor, for which the best possible illumination will be provided, is to be given over to the great library hall and its auxiliary rooms, while the floor immediately below the reading rooms will ultimately be used for book stacks. Facilities for photographic reproduction, drawing and the like are also provided.

Eight alcoves open into the large central library room, devoted to general reference books, reference periodicals, the books of the American Institute of Electrical Engineers, of the American Society of Mechanical Engineers and of the American Institute of Mining Engineers and to the periodicals of each of these three societies. The union library thus arranged for should be of immense service to each of the societies represented and extremely useful to the whole engineering profession. The public will be given free access to the most important engineering library in the country.

It is expected that the building will, by the office and meeting accommodations it is designed to offer, prove an important means of advancing the interests of numerous engineering and quasi-engineering societies and indirectly of promoting the solidarity and efficiency of the scientific profession of engineering.

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING

The trustees of the Carnegie Foundation have adopted rules for granting retiring allowances which are characterized by foresight and wisdom. The question of charity has been so carefully eliminated that the plan will dignify the profession of teaching and will directly and indirectly improve the conditions in our institutions for higher education. There remain, of course, the fundamental issues between variety and uniformity, flexibility and permanence, autonomy and centralization, individualism and socialism. It can not be doubted that this great foundation favors centralization and a caste of professors. But there seems to be no other solution of the complicated problems of modern civilization than industrial socialism relieved by intellectual individuality.

The provisions for granting normal retiring allowances are as follows:

1. A normal retiring allowance is to be awarded to a professor in an accepted university, college or technical school, on the ground of either age or length of service. The term professor, as here used, is understood to include presidents, deans, and other administrative officers, professors, associate professors and assistant professors, in institutions of higher learning.

2. Retiring allowances shall be granted under the following rules, upon the application of the institution with which the professor is connected.

3. In reckoning the amount of the retiring allowance the average salary for the last five years of active service shall be considered the active pay.

4. Any person sixty-five years of age, and who has had not less than fifteen years of service as a professor, and who is at the time a professor in an accepted institution, shall be entitled to an annual retiring allowance computed as follows:

(*a*) For an active pay of sixteen hundred dollars or less, an allowance of one thousand dollars, provided no retiring allowance shall exceed ninety per cent. of the active pay. (*b*) For an active pay greater than sixteen hundred dollars the retiring allowance shall equal one thousand dollars, increased by fifty dollars for each one hundred dollars of active pay in excess of sixteen hundred dollars. (*c*) No retiring allowance shall exceed three thousand dollars.

5. Any person who has had a service of twenty-five years as a professor, and who is at the time a professor in an accepted institution, shall be entitled to a retiring allowance computed as follows:

(*a*) For an active pay of sixteen hundred dollars or less, a retiring allowance of eight hundred dollars, provided that no retiring allowance shall exceed the active pay. (*b*) For an active pay greater than sixteen hundred dollars, the retiring allowance shall equal eight hundred dollars, increased by forty dollars for each one hundred dollars of active pay in excess of sixteen hundred dollars. (*c*) For each additional year of service above twenty-five, the retiring allowance shall be increased by one per cent. of the active pay. (*d*) No retiring allowance shall exceed three thousand dollars.

6. Any person who has been for ten years the wife of a professor in actual service may receive during her widowhood one half of the allowance to which her husband would have been entitled.

7. In the preceding rules, years of leave of absence are to be counted as years of service but not exceeding one year in seven.

8. Teachers in the professional departments of universities whose principal work is outside the profession of teaching are not included.

9. The benefits of the foundation shall not be available to those whose active service ceased before April 16, 1905, the date of Mr. Carnegie's original letter to the trustees.

Institutions supported by the state were excluded by the terms of the original gift, but this provision has not been included in the act of incorporation and the question is under consideration. Institutions controlled by a religious organization, requiring sectarian tests, or teaching distinctly denominational tenets are excluded. The fact that a university such as Chicago is excluded, while a college whose spirit is essentially sectarian may be accepted, will at first work inequality, but the institutions will doubtless adjust themselves to the conditions. It would probably have been better if the denominational question had been ignored. A sectarian university is a contradiction in terms, as an institution can not be at the same time sectarian and a university, but under existing conditions a certain amount of denominational control seems to be innocent enough, especially in the case of small colleges. The definition of a college, based in part on the New York state ordinance, is as follows:

An institution to be ranked as a college, must have at least six professors giving their entire time to college and university work, a course of four full years in liberal arts and sciences, and should require for admission, not less than the usual four years of high school preparation, or its equivalent. A technical school, to be eligible, must have entrance and graduation requirements equivalent to those of the college, and must offer courses in pure and applied science of equivalent grade. To be ranked as a college an institution must have a productive endowment of not less than two hundred thousand dollars.

SCIENTIFIC ITEMS

We regret to record the deaths of Professor Israel Cook Russell, head of the Department of Geology at the University of Michigan, of Walter F. R. Weldon, F.R.S., Linacre professor of comparative anatomy at Oxford University, and of M. Pierre Curie, professor of physics at the Sorbonne, Paris, eminent with Mme. Curie for the discovery of radium.

Stanford University suffered severely by the recent earthquake, the loss being estimated at nearly $3,000,000. The buildings totally wrecked are the church, the memorial arch and the new library and gymnasium buildings. The buildings occupied by the laboratories and lecture rooms are not seriously damaged, and the university will be able to resume its work at the opening of the next term on August 23. The University of California suffered but little injury, either at Berkeley or San Francisco. Buildings owned by it in San Francisco, however, were destroyed and will seriously curtail its income, which will also suffer by the decrease of taxation in the state, unless this is made good by the legislature. The University of the Pacific suffered to the extent of about $60,000 with its buildings and collections. The building of the California Academy of Sciences was completely burned, but the type specimens and records were saved.

The New York legislature has passed a bill providing for a new building for the State Museum, State Library and the Education Department, to cost not more than four million dollars. The bill carries an appropriation for the acquisition of a site and the preparing of plans. The legislature also passed a bill to acquire Watkins Glen, one of the ravines running into the Finger Lakes of western New York, for a state reservation. This region was described by Professor Tarr in the last issue of the MONTHLY.

DR. E. RAY LANKESTER, director of the British Museum of Natural History, has been elected president of the British Association for the meeting to be held this year at York.—Dr. Henry H. Donaldson, since 1892 professor of neurology at the University of Chicago, has been elected professor of neurology at the Wistar Institute of Anatomy, Philadelphia.—Dr. K. E. Guthe, associate physicist at the National Bureau of Standards, has been appointed professor of physics and head of the department of physics at the State University of Iowa.

THE late Stephen Salisbury, of Worcester, Mass., has bequeathed the residue of his estate to the Worcester Art Museum, which, it is said, will receive more than $3,000,000. Many other public bequests have been made by the will, including, in addition to $200,000 to the Worcester Polytechnic Institute, some $250,000 to the American Antiquarian Society and $5,000 and a site for a building for the Worcester Natural History Society.

THE yacht *Galilee*, engaged in the magnetic survey of the North Pacific Ocean under the auspices of the Department Terrestrial Magnetism of the Carnegie Institution of Washington, arrived at San Diego some time ago, having completed a successful series of magnetic observations embracing the regions between San Francisco, San Diego, Honolulu, Fanning Island and the magnetic equator.—Dr. Sven Hedin has proceeded to Persia, where he proposes to explore thoroughly, from a scientific point of view, the salt deserts of Dasht-i-Kavir and Dasht-i-Lut in the eastern part of the country. He hopes afterwards to proceed through Afghanistan to India, and there organize an expedition for the exploration of Central Tibet.—Professor C. S. Sargent, of Harvard University, has sailed for Chili and the mountains of South America to obtain specimens for the Arnold Arboretum.

THE endowment fund for increase of salaries, at Harvard University amounts to nearly $2,300,000. The scale of salaries is to be as follows:

Instructors:	
Upon appointment	$1,200
Yearly increase	100
Maximum	1,500
Assistant Professors:	
In the first five-year term	2,500
In the second five-year term	3,000
Associate Professors:	
Upon appointment	3,500
Maximum	4,500
Professors:	
Upon appointment	4,000
Maximum	5,500

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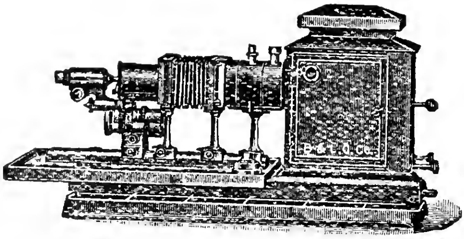

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For the best memoir presented a prize of sixty dollars may be awarded; if, however, the memoir be one of marked merit, the amount may be increased to one hundred dollars, at the discretion of the Committee.

For the next best memoir a prize not exceeding fifty dollars may be awarded.

Prizes will not be awarded unless the memoirs presented are of adequate merit.

The competition for these prizes is not restricted, but is open to all.

Attention is especially called to the following points:

1. In all cases the memoirs are to be based on a considerable body of original and unpublished work, accompanied by a general review of the literature of the subject.
2. Anything in the memoir which shall furnish proof of the identity of the author shall be considered as debarring the essay from competition.
3. Preference will be given to memoirs showing intrinsic evidence of being based upon researches made directly in competition for the prizes.
4. Each memoir must be accompanied by a sealed envelope enclosing the author's name and superscribed with a motto corresponding to one borne by the manuscript, and must be in the hands of the Secretary on or before April 1st of the year for which the prize is offered.
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Boston, Mass., U. S. A.

GLOVER M. ALLEN,
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